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A METHOD FOR THE LOCALIZATION OF FOREIGN BODIES IN THE EYE[1]

By ROY KEGERREIS, M.D., CHICAGO

THE localization of foreign bodies within the eye by means of X-rays has gained tremendously in importance with the increase in industrial accidents. It is impossible to demonstrate roentgenographically a foreign body in a large percentage of patients who are referred for examination. As a rule, preliminary roentgenograms are made in order to determine whether or not a foreign body is present, to eliminate the painstaking work which is necessary for an exact localization. Many workers take postero-anterior stereoscopic views of the skull for the preliminary examination, but there are various kinds of non-metallic foreign bodies which are liable to be invisible with this type of technic because of the absorption of the X-rays by the overlying brain and calvaria. It is better practice to take one postero-anterior view of the entire skull to show both eyes, since adjacent sinus, dental, or other pathology is frequently present and it is always advantageous to be able to compare the other side. An oblique lateral view, with the injured side nearest the film and the rays coming slightly from the front, should also be taken; in this manner a maximum of contrast is obtained. The two roentgenograms will enable a preliminary estimate to be made of the size, shape, location, and character of the foreign body, if it is apparent.

The patient may be examined by fluoroscopy, but the lack of evidence of the presence of a foreign body should not be considered as evidence in a positive sense. If the foreign body is opaque to X-rays and is of considerable size, fluoroscopy is frequently helpful as a means of preliminary localization.

It is common practice to take lateral and either anteroposterior or postero-anterior views when studying fractures or other traumatic lesions of the extremities. In such work, the bodies to be localized are frequently multiple and the necessary precision is more of a gross character than is the case in work with the eye in which the foreign body is usually quite minute and the localization must be as exact as possible. In examining an extremity, right-angle views are very helpful in giving a true picture of the conditions. These same advantages do not hold for the work of localization of foreign bodies in the eye, because it is often exceedingly difficult, or even impossible, to identify corresponding parts of single or multiple foreign bodies. The difficulty in identifying corresponding parts does not exist, to a great extent, if the tube shift is such that there is an angle of, say, 30° between the beams of X-rays, yet the accuracy of the

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

localization from measurements of shift of images is only slightly decreased. It might be pointed out that the accuracy of localization of foreign bodies in the eye is not limited by the accuracy of the measurements on the roentgenogram, but, rather, because of the less apparent inaccuracies of alignment and the unknown factors of individual anatomic variation. It should be noted that "the actual localization is made with reference to the marker in front of the eye and not with reference to the structures of the eye."

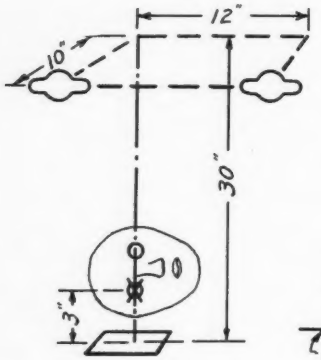

Fig. 1-*A*.

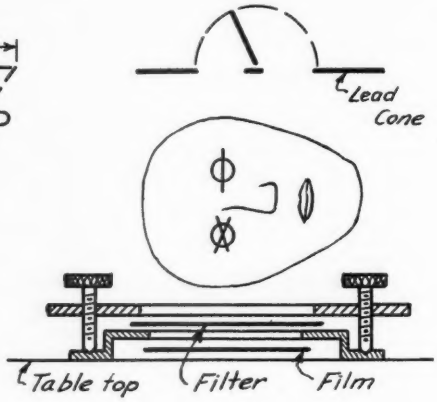

Fig. 1-*B*.

GENERAL METHODS OF LOCALIZATION

All methods depend on one or another system of three-dimensional triangulation; two roentgenograms are made and measurements are taken from them. Graphic solutions, which have been used generally, are most beneficial when the construction is carried out and superposed on data that already exist on the sheet of paper. The necessary computations of analytic methods for the determination of the position of a foreign body may be made by one who does not possess sufficient working knowledge of geometry and trigonometry to understand the derivation of such methods, just as is the analogous case with graphic solutions.

SWEET LOCALIZER

The apparatus which was developed by the late Dr. Sweet is probably the most generally accepted and used in this country. Excellent work can be done with it but

(1) The cost of the apparatus is considerable;

(2) The apparatus is heavy to handle and rather bulky to have about;

(3) It is not feasible to observe the injured eye while the exposures are being made;

(4) The terminals of the X-ray tube are rather near the patient.

The following dimensions are approximated in this apparatus:

16.7 in., perpendicular distance from the target to the plane of the photographic emulsion;

3 in., center of the eye to the plane of the photographic emulsion;

7 in., tube shift between exposures;

25°, angle between the X-rays and the frontal plane of the patient.

The obliquity of the X-rays with the

frontal plane of the patient's face is used in order to "throw out" the shadow of the opposite eye, secure a bone-free exposure of the cornea, and have the X-rays penetrate a minimum of tissue. All of these conditions are very desirable.

TELERADIOGRAPHY

Teleradiography assumes that

(1) The X-rays approach parallelism;
(2) There is good definition;
(3) There is very little magnification or distortion in the photographic image.

These conditions are secured by relatively long target-film distances, short object-film distances, and, to a certain extent, by the use of an X-ray tube with a small focal spot. Very often the perpendicular distance from the object to the plane of the film is not considered sufficiently. The ratio of the target-film distance to the object-film distance gives an index of the effective parallelism of the rays.

A recent article by Ahlbom (1), which very thoroughly reviews the literature on foreign body localization in the eye, presents a new teleradiographic triangulation method for the localization. Two views are taken at right-angles with a target-plate distance of 2.75 meters, but the object-plate distances are about 12.5 and 25 centimeters. There are then target and object distance ratios of approximately $275 \div 12.5 = 22$ and $275 \div 25 = 11$. In the Sweet localizer the corresponding ratio is $16.75 \div 3 = 5.6$. In the arrangement which is being suggested (Fig. 1-*A*) the ratio is $30 \div 3 = 10$.

It is seen that the parallelism of the rays, according to this ratio measurement, is about twice that of the Sweet method and compares favorably with that of Ahlbom's so-called teleradiographic method, yet the target-film distance is considerably less than one-third his value.

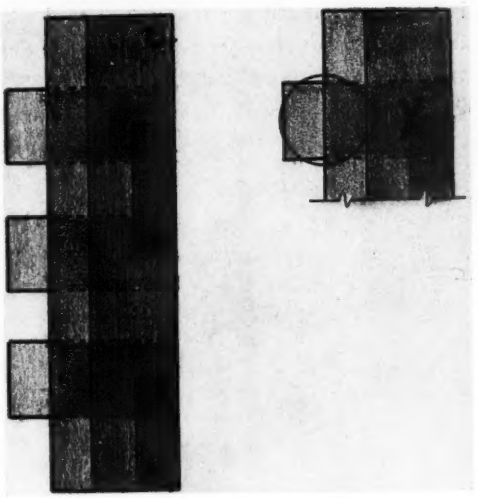

Fig. 2-*A*. Fig. 2-*B*.

STEPPED FILTER

Ahlbom has suggested the use of a wedge-shaped filter of aluminum to avoid the over-exposure of certain areas and, in particular, to cause the cornea to be apparent on the roentgenograms. This is a very excellent method of eliminating the over-exposure of certain parts. A similar adaptation of a filter is made in the method which is being described. However, the filter, rather than the photographic emulsion, is used as the reference plane and it is made stepped so that a system of rather special rectangular co-ordinates is apparent on the roentgenograms (Fig. 2-*A*). Although the stepped filter and the film should be parallel, this need be only approximate, since measurements are taken from the roentgenograms by means of proportional scales that automatically correct for any possible distortion which may exist, because of non-parallelism or because of expansion or shrinkage of the film. The amount of irregular distortion of a roentgenogram within any one of the rather small elemental rectangles will, quite obviously, be negligible. The co-ordinate system is apparent on the roentgenograms,

but it is not obtrusive and, in general, the filter tends to make the foreign body more conspicuous without there being any chance of occluding it.

Copper is employed as the filtering material, rather than aluminum, since it can be much thinner for the same absorption. As a result, the edges of the co-ordinate rectangles are definite. The filter varies from 1/20 to 1/2 mm. in thickness.

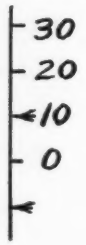

Fig. 3-*A*.

Fig. 3-*B*.

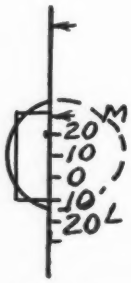

Fig. 3-*C*.

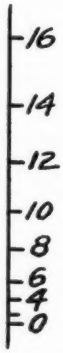

Fig. 3-*D*.

ALIGNMENT OF PATIENT

The patient's head, with the injured side down, rests on a framework which is independently supported by three levelling screws (Fig. 1-*B*). The head is pressed down firmly by means of sandbags and it can be raised, lowered, or even tilted by manipulating the three levelling screws.

The visual axis is not the geometric axis of the eye and, for that reason, the patient should gaze 5° nasalward in the median horizontal plane.

The fiducial marker which is placed 1 cm. before the injured eye is a metal cross that shows on the roentgenograms. The marker which is placed before the uninjured eye is a straight edge of non-opaque material. The two markers are so fastened to the stepped filter as to be in a line perpendicular to it while the patient is being positioned. The stepped filter is held by spring friction and can be moved about in its plane quite easily. The head is raised or lowered and the stepped filter, with the attached fiducial markers, is moved about until the wire cross is exactly 1 cm. in front of the middle of the cornea of the injured eye; the head is tilted until the upper marker is also 1 cm. away from the cornea of the uninjured eye and passes directly before its center. The alignment of the filter, fiducial marker, patient's head, and target of the X-ray tube has not been correct if the relations shown in Figure 2-*B* do not exist in the roentgenograms. It is thus seen that a rather good check can be had almost at a glance, since some of these relations can be made out on the roentgenogram.

A sheet of lead is placed above the patient's head to "cone down" the X-rays.

MEASUREMENT AND CALCULATIONS

Three co-ordinates are required to locate a point in space; the specification of the position of a foreign body in the eye is no exception to this law. The three co-ordinates are derived from measurements which are

taken from the two roentgenograms by means of special proportional scales that automatically make the dimensions correspond to those in the plane of the stepped filter. Numerous scales, which vary in magnitude by about 1 per cent, are provided and measurements are made with the scale, which, in the desired direction, exactly match the width of the elemental rectangle that contains the image of the foreign body.

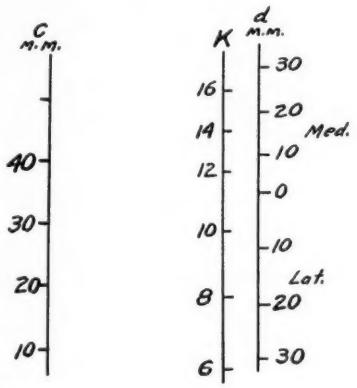

Fig. 4-*A*.

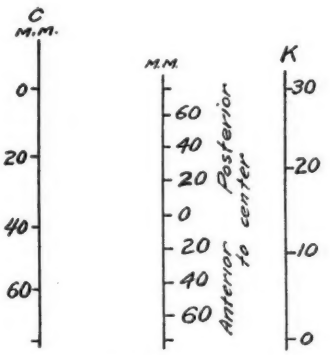

Fig. 4-*B*.

DISTANCE FROM MEDIAN HORIZONTAL PLANE, VERTICAL LOCATION

The distance that the foreign body is above, or below, the median horizontal plane of the eye can be measured directly from the first roentgenogram, in which the target of the X-ray tube was on a level with the eye and 10 inches anterior to the fiducial markers. The scale is calibrated directly in millimeters and is "laid out" on the assumption that the rays through the sagittal plane are parallel (Fig. 3-*A*). This is, admittedly, an approximation, but it entails a possible maximum error of only about one-fifth millimeter and it simplifies the necessary mathematical manipulations.

DISTANCE FROM SAGITTAL PLANE, LATERAL OR MEDIAL LOCATION

The distance of the foreign body from the sagittal plane of the eye is obtained by means of two measurements, one from each of the roentgenograms (see appendix below). The measuring scale is placed vertically so that its 0 coincides with the image of the foreign body on the first roentgenogram in which the target of the X-ray tube was on a level with the injured eye. The place on the scale at which it crosses the lower edge of the horizontal filter band is noted (Fig. 3-*B*). A scale which has been found to match the width of the horizontal filter band in the other roentgenogram in the region of the image of the foreign body is so placed that the value which was just previously noted on the scale over the first roentgenogram is over the corresponding filter band edge, and the distance from the foreign body to the sagittal plane can now be read directly from the scale (Fig. 3-*C*).

ANTEROPOSTERIOR LOCATION

The distance of the foreign body from the sagittal plane and the horizontal distance of the image of the foreign body from the im-

age of the fiducial marker are used to make the calculation of the anteroposterior location. The measurement of the horizontal location of the image of the foreign body is made from the edge of one of the vertical

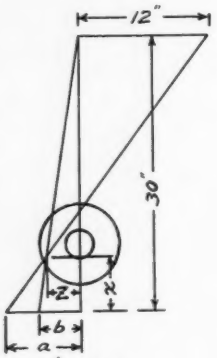

Fig. 5-*A*.

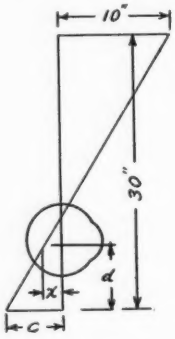

Fig. 5-*B*.

filter bands. This measurement should be the same on each of the two roentgenograms. If the latter are not the same within the general accuracy of the work, the exposures should be repeated. This, of itself, is a good check on the accuracy of the set-up of the apparatus.

The anteroposterior location of the foreign body is obtained by means of a so-called "alignment chart" and a graphic subtraction (Fig. 4). The two known values on the outer scales of the alignment chart are connected by a straight edge or stretched thread, and the anteroposterior location is found by subtracting the reading of the middle scale (K) from the measured horizontal distance given above. The subtraction is accomplished by connecting the corresponding values of the outer scales of the chart of Figure 4-*B*.

PHYSIOLOGIC METHOD

Frequently the location of the foreign body is determined to be such as to leave some doubt as to whether it is within or without the orbit. The making of roentgenograms when the patient gazes in different directions will produce a shift of the image of the foreign body if it is within the eyeball, fastened to it or its appendages. No motion will be shown if the foreign body lies in the axis of rotation, or if the two positions are in the same ray, causing the two images to be superposed on the roentgenogram, even though rotational motion has taken place. The underlying principles of this method have been fully discussed by several authors.

DISTANCE FROM THE CENTER

The ophthalmologist who receives the report is usually desirous of knowing at what point the wall of the eyeball is nearest the foreign body, and how near it is. The square root of the sum of the squares of the three distances which have been found gives the radial distance from the center. This, subtracted from the radius of the eye, gives the distance from the outside of the eyeball. A special scale (Fig. 3-*D*) is used to perform the calculation. With it, three lengths are laid off end-to-end, which are proportional to the squares of the distances from the center of the eye. The combined total length of the three lengths, when measured by the scale, gives the desired square root of the sum of the squares. The diameters of eyes vary considerably, but, as a starting point, an eyeball with a diameter of 24 mm. is assumed, with a corneal bulge 1 mm. thick and 8 mm. radius. Normal eyes will vary nearly as much as 10 per cent from this. Injured eyes may vary more, because of edema, hemorrhage, shrinkage, or even collapse on account of the actual loss of fluid. The referring ophthalmologist is quite obviously the one to allow for such conditions.

RÉSUMÉ

In the method which is being described, the position of the patient is such that the injured eye can be observed during the ex-

posures. It is suggested that this be done by means of a short range telescope with a magnification of about two or three diameters.

It seems that there have been no reported cases in which the foreign body was not rigidly fixed inside the orbit and did not turn consistently with it. Such a case is a possibility and should be considered if the results appear bizarre.

Any difference in the sharpness of the images in the two roentgenograms should lead to rejection of them, because poor definition is almost sure evidence of motion. There is always a great advantage in repeating the work, since then a check is possible.

If the foreign body is in the cornea or adjacent structures, valuable information may be secured by inserting a small film above, below, or alongside of the eye and using the so-called "soft tissue technic" (2).

The principle embodied in the stepped filter may be applied to any method of localization.

This method should prove satisfactory because of the following conditions:

(1) Films with or without intensifying screens may be used. No glass plates, special envelopes, or developing holders are required.
(2) The film is near the injured eye and the target-film distance is relatively great.
(3) The stepped filter and fiducial markers are easily adjusted.
(4) There are refinements in aligning the patient's head.
(5) It is necessary to position the patient only once; he need not be disturbed between exposures.
(6) The X-rays penetrate a minimum of tissue.
(7) Scatter is minimized by a coning down of the X-ray beam to a minimum.
(8) The cornea is made apparent.
(9) The injured eye is observed while the exposures are made.
(10) Inherent checks exist.
(11) A complete specification is secured.
(12) The required apparatus is relatively simple and inexpensive.
(13) There is ample clearance between the high voltage conductors and the patient.

APPENDIX

Distance from the Sagittal Plane, Lateral or Medial Location (Fig. 5-*A*).—By the law of similar triangles the following proportions may be set up:

(1) $(30 - x) : z :: x : (b - z)$
(2) $(30 - x) : (z + 12) :: x : (a - z)$

Equating the product of the means to the product of the extremes gives:

From (2) $zx + 12x = (a - z)(30 - x)$
(1) $zx = (b - z)(30 - x)$

Subtracting

$$12x = (a - b)(30 - x)$$

Solving for x

$$x = 30(a - b) / 12 + (a - b).$$

We measure *a* and *b* on the roentgenograms. This expression for the distance of the foreign body from the plane of the filter depends on only one variable, $(a - b)$, and, accordingly, a scale can be constructed to give x in terms of the difference between the two lengths *a* and *b* (Figs. 3-*B* and 3-*C*). The scale may be calibrated in distance from the sagittal plane by the subtraction of a constant from the value of x.

Anteroposterior Location (Fig. 5-*B*).—By the law of similar triangles

$$d : (c - x) :: 30 : (10 + c)$$

Equating the product of the means to the product of the extremes and solving for x gives

$$x = c - (d/30)(10 + c).$$

We secure *c* by measurement and *d* by calculation. The expression on the ex-

treme right is calculated by means of the alignment chart (Fig. 4-*A*).

REFERENCES

(1) Ahlbom, H.: A New Method of Localizing Foreign Bodies in the Eye. Teleradiography with Visualization of the Cornea. Acta Radiol., 1931, XII, 212-235.
(2) Wieser, S.: Weitere Mitteilungen über die skelettfreie Röntgenaufnahme des vorderen Bulbusabschnittes nach Prof. Dr. Vogt. Klin. Monatshl. f. Augenheilk., Aug. 31, 1928, LXXXI, 234-253.

DISCUSSION

Dr. Robert R. Newell (San Francisco): I would like to know whether the triangulation of that foreign body is done with reference to the height above the surface of the film or if it is done in regard to the eyeball. Does the shadow of the eyeball show with sufficient clearness so that you measure its relation to the height of the eyeball?

One needs, for localization of foreign bodies in the eye, better than millimeter accuracy. It often makes all the difference in the world whether a foreign body is inside or outside the eyeball. Inasmuch as many foreign bodies hang up against the sclera, that question comes up very often.

I would like to ask if you tried your localization on known foreign bodies in the eye. Occasionally I have checked the position of a foreign body in the eye by putting marks on the eye. Take some thin silver wire and wrap it into a spiral, then clip off pieces to make very small rings of about a millimeter in diameter, open just wide enough, which you can clip to the conjunctiva at the limbus. I have had occasion to put on two of these at opposite ends of a diameter of the cornea, and localized them and the foreign body at the same time, in order to be sure of the position.

Dr. Gentz Perry (Evanston, Ill.): I was quite impressed with the nicety with which the position of the head may be adjusted with this apparatus. I think that is really a very nice point of improvement, as shown by this technic.

I would like to ask the essayist, in relation to the question just asked, if the foreign body is within the eyeball. The essayist mentions the movement of the foreign body as shown by different views, if they are made in relation to the movement of the eyeball. He uses the term "orbit." I am not quite certain whether, in his paper, he means the bony orbit or the eyeball. I would like to have him bring out that point.

I am quite impressed with what should be a very accurate localization. I think that there are certain improvements in the technic shown that are well worth our consideration.

Dr. Kegerreis (closing): It can be stated that the filter plane is taken as the plane of reference.

The use of a wire loop, which Dr. Newell has originated in localization, is very excellent and has many advantages. Its only disadvantage, as I see it, is that an additional very slight trauma is inflicted on the outer surface of the injured eye.

ROENTGEN DIAGNOSIS OF LESIONS IN THE SMALL INTESTINE[1]

By HORACE W. SOPER, M.D., St. Louis, Missouri

SINCE publication of an article in August, 1929,[2] I have been able to formulate more accurately the interpretation of atypical patterns in the small intestine as they appear upon the X-ray films. Increased experience has led to the diagnosis of a larger number of cases presenting obscure symptoms. Differential diagnosis between diverticula, adhesions, and new-growths is of chief interest and I shall confine my paper to that subject.

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

[2]Am. Jour. Roentgenol. and Rad. Ther., August, 1929, XXII, 107–119.

In attempting to make the diagnosis of small intestinal lesions, the roentgen-ray technic is of extreme importance. *First,* the patient must be examined in the upright posture. *Second,* begin to look for abnormalities in the small intestinal pattern from the two and one-half to the six-hour period. They are often encountered just about the time the last part of the barium meal leaves the stomach. *Third,* secure a film of the suspicious area at once and continue to watch for other overfilled loops, recording at once. The shadows are apt to be evanescent. It is a mistake to expect them to be persistent. Remember that you are searching for evidence of partial and not complete obstruction.

The vast majority of adhesions are post-operative in character but some are produced by former inflammatory processes. I have designated the usual adhesions that follow appendectomy as *Grade 1.* In this type the coils of the terminal ileum are matted together, *i.e.,* adherent to each other. No symptoms are produced by this form.

In adhesions of *Grade 2,* one or more bands are formed which attach a coil of the gut to some neighboring organ or to the abdominal wall. This type may produce no symptoms; however, it forms a trap that may catch a loop of the bowel and produce acute obstruction. Often a patient gives a history of several attacks of partial obstruction, *with complete absence of symptoms between the attacks.* The most careful X-ray examination may fail to disclose these bands, but the alert observer will usually find atypical dilated coils.

Adhesions of *Grade 3* form definite bands which bind down the intestine and form a partial stenosis of the lumen and interfere with function, as illustrated by the adhesive bands that constrict the terminal ileum. This type is more easily demonstrated by roentgen examination. The symptoms are usually dull pain located in the region of the constriction, intermittent in character, often nausea and anorexia. A history of partial attacks of obstruction is usually obtained.

It is obvious that adhesions of all three types may exist in the same patient.[3]

The *post-operative treatment* is of extreme importance. We must avoid everything that might incite peristaltic movement of the small intestine. During the first 72 hours after operation the following rules must be rigidly enforced:

1. No food or water to be given by mouth. Frequently moisten the tongue and lips with cold water to maintain salivary secretion, thereby preventing possible ascending infection, particularly of the parotid gland.

2. The patient to be sustained by the free use of intravenous glucose and saline solution.

3. No vomiting to be permitted. The Levin intra-nasal catheter is to be kept in the stomach and the contents siphoned until all danger from accumulation of gastric secretion is over.

4. Permit no enema or passage of the colon tube.

5. Permit no laxative to be given.

6. The patient is to be kept under the constant influence of morphine, given hypodermatically by the "overlapping method," *i.e.,* every four to six hours in doses sufficient to produce mental calm and physical rest. The dosage will vary from 1/12 to ¼ grain. Care must be exercised that the patient does not emerge from the morphia influence until the 72-hour period has elapsed. After this time the usual symptomatic treatment is employed.

In my series of patients, 20 cases of diverticulum of the duodenum and 12 cases of diverticulum of the jejunum were encountered. None of the patients developed symptoms that could be traced to the di-

[3]Films were shown from which the essayist demonstrated the three grades differentiated.

verticulum. Recently Morrison and Feldman[4] reported a case of carcinoma occurring in a duodenal diverticulum.

Twenty-four-hour stasis in the ileum must be regarded as a pathologic condition. Heed must be given Case's warning that the 9-hour film may show an empty ileum, while the 24-hour observation may reveal barium in the terminal ileum because of regurgitation from the cecum. Of course, it is obvious that barium may be present in the ileum 24 hours after a barium meal in cases of pyloric obstructive lesions. Operative confirmation was obtained in 20 of the patients: definite obstructive disease was disclosed in all of them.

In cancer of the small intestine, the dilated atypical loop is usually irregular in contour and is surmounted by a small gas bubble. The test for occult blood is positive in nearly every case of small intestinal malignancy. The diverticulum of the small intestine is usually of smooth contour and is rarely surmounted by a gas bubble.

There are four sources of error in the interpretation of small intestinal patterns, and I would emphasize a few guiding precepts.

(1) Never examine a patient in an attack of abdominal pain.

(2) Never examine a patient after a purgative.

(3) Never pass on a patient during an attack of diarrhea.

(4) Finally, never make the mistake of looking for complete obstruction. You will often find this about the terminal ileum, but those films which are truly important are the ones taken from the second to the sixth or eighth hour after the barium meal.

[4]Morrison, T. H., and Feldman, M.: Ann. Clin. Med., October, 1926, V, 326.

CONCLUSION

Intensive study of the course of the barium meal in its passage through the small intestine is necessary in order to establish the diagnosis of pathologic conditions. Careful palpation may disclose the presence of a small movable tumor that will lead to the diagnosis of a lesion in the small intestine. Routine examination of the feces for occult blood is of extreme importance in the detection of malignant ulcerative growths in the small intestine.

ROENTGENTHERAPY IN ARTHRITIS[1]

NEW ASPECTS AND TECHNIC

By HEINZ LANGER, M.D.
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MAY I take it for granted that everyone interested in the treatment of arthritis, and its etiology and pathology, has familiarized himself with Dr. Pemberton's excellent book, "Arthritis and Rheumatoid Conditions" (1)? The classification of the numerous types of this ailment demonstrates how little we are informed about one of the oldest and most common diseases in the world. Aside from arthritis produced by well known infections, such as tuberculosis, syphilis, and gonorrhea, as well as arthritis urica (gout), we have to distinguish two major groups of chronic arthritis.

1. The atrophic type of arthritis, called in England "rheumatoid" arthritis, shows at first only inflammatory reaction of the bones in the region of the joints, with very little osteoporosis present. In the later stage, decalcification will be observed, disappearance of cartilage followed by narrowing of the

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

interarticular space, and, finally, fusion of the articular surface with complete ankylosis. There was, or still is, present, somewhere in the body, a real inflammatory process as expressed in the blood picture if we find leukocytosis with polynucleosis in the beginning of the disease; also the sedimentation time is often found to be more rapid. There is always an effusion of the joints in the beginning. This might be of the exudative type, when the effusion will last for quite a time; or it may be of the fibrous type, in which the effusion disappears in a short time.

2. The hypertrophic type, or arthrosis, shows marked deformity of the contours of the bone. Spur formation, osteophytes, or parrot-beak formation, will be seen in the X-ray film, but early decalcification will not be observed. The hypertrophic arthritic patient may show metabolic disturbances, symptoms of general endocrine imbalance, and, often enough, he gives evidence of constant mechanical trauma. The result of strain and stress of life appears in some persons in this form of arthritis.

In his report the roentgen diagnostician should never fail to pronounce an arthritic patient as hypertrophic or atrophic. When the hands are affected, the differentiation can be made easily and early. It is possible that both kinds of arthritis may be seen roentgenologically in a single patient, which makes the treatment and clinical management more complicated. That roentgentherapy can be of value in treating this disease is not so generally accepted.

The treatment of arthritis with X-rays dates back to Sokolow (2) in 1897. As early as 1898, Stenbeck (3) reported 52 cases of chronic arthritis of which 80 per cent could be improved by X-ray therapy. The first report in this country was made by Anders, Daland, and Pfahler, in 1906 (2). Clinically and roentgenologically their patients showed great improvement after the X-ray treatment.

Edsall and Pemberton (4) reported one case of arthritis treated by X-rays. Their publication was a warning to roentgenologists, for the toxic reaction after X-ray was, in their opinion, too dangerous. Pemberton (5) repeated his warning. Every roentgenologist who tried X-radiation in arthritis observed the same phenomenon, namely, increased pain starting after a few hours of exposure, with, sometimes, general malaise symptoms, seemingly of toxic origin (as described by Edsall and Pemberton), lasting for from one day to two weeks. The explanation given by the internist or roentgenologist (sudden tissue breakdown, with inability of the organism to take care of this invasion of dead tissues in the blood stream) did not satisfy everyone. In spite of the results observed after this reaction of increased pain had passed, the treatment of arthritis with X-rays was abandoned. Reports appeared sporadically in the roentgen literature praising the analgesic effect of X-ray treatment in arthritis. This phenomenon was explained as a direct effect on the lymphocytes and leukocytes which had invaded the nerves and were broken down through X-ray therapy, thereby reducing the tension in the nerve sheath. Undoubtedly X-rays affect the lymphocytes and leukocytes in an inflamed area, but this breaking down of blood tissues does not satisfactorily explain all the effects of radiation.

In 1921 I started to study the effect of roentgen and radium rays on nerve tissues. The general opinion at that time was that nerve tissues are highly roentgen-ray resistant, which is true so far as motor and sensory nerves and brain tissue are concerned. A few writers had expressed the opinion that X-rays or radium might have a positive effect on the vegetative nervous system, but only theories were offered. My animal experiments (6) brought me to the following conclusions: X-rays or radium affect the vegetative nervous system, first with a stimulation (Stage 1) lasting for from several

hours to a week or, rarely, two weeks, which passes finally to a paralyzing or quieting effect of the treated nerve (Stage 2). The effect can be observed much more easily as the nerve is in a condition of hyperactivity. This observation has been proved to be correct by Zimmern and Chailley-Bert, Gabriel (10), Lazarus and Dunbar (11), Redfield, Forbes (12), and others.

Are there symptoms of vegetative nervous disturbances present in arthritis? To answer this question let us see what is our conception of arthritis. The general opinion to-day is that the first factor to produce an arthritic condition is a bacterial infection. Whether this infection remains local or spreads more or less over different parts of the body most probably is not of such great importance. The second factor is the individual reaction of the body toward the infection. This reaction is explained to-day by most authorities as an anaphylactic reaction.[2] The clinical manifestations, with their typical X-ray findings, are variable and are based upon an inherited or acquired condition of the body. The vegetative nervous system seems to play a very important rôle in any anaphylactic reaction, most probably under the influence of a biochemical effect.

Pemberton has directed a great deal of research to the question of circulatory changes in arthritis. The system seems to be in a state of over-irritation, produced by the anaphylactic reaction. It can be readily understood that vasoconstriction interferes with a good blood supply to the surrounding muscles and tendons, and to joints with poor blood supply. That spastic contraction of the peripheral arteries commonly gives rise to pain is generally conceded. The presence of pain, even when the patient is in perfect rest, might be partly due to the spastic contraction of the blood vessels in the diseased area of the body. We also have studied our arthritic patients from the standpoint of skin temperature taken by readings. Lowered temperature of the affected area was usually observed, which confirms the findings of Adson and Rowntree (13), Hench (14), and others.

[2]We understand under allergy (v. Pirquet, 1906) the changed reaction of the body produced through infection, bacterial products, or other foreign body substances. It is an antigen-antibody reaction. Anaphylaxis is nothing more than a special case of allergy, as is idiosyncrasy.

APPEARANCE OF THE SKIN

We know that the appearance of a shiny, glossy skin, sometimes in combination with edema of the underlying tissues, is explained as due to trophic changes and, as such, is identified with disturbances of the vegetative nervous system. Very often the nails show trophic disturbances, their symmetrical appearance pointing strongly toward the vegetative nervous influence. These clinical signs, sometimes combined with a symmetrical appearance of dermatitis, mostly on the lower extremities, have been frequently found in our arthritic patients.

INTERNAL SECRETION

Menge (15) found arthritis in women of the climacteric age to be practically always bilateral. Riebold (16) presents a whole group of arthritic patients with endocrine disturbances and points to the sclerodermatic changes of the skin, vasomotor disturbances, and erythema resembling urticaria. Heidenhain (17) speaks of senile, symmetrical, bilateral arthritis. In describing the hypertrophic type of arthritis in its roentgenologic aspect Pemberton says: "Although the patient may not be aware that both knees are affected, the X-ray picture will usually show bilateral involvement of bony tissue, even though one knee is without pain and seems to have normal function." He does not say it, but a certain symmetrical involvement of the bony tissues, it seems to me, can be frequently observed. This is a sign which points to the influence of the vegetative nervous system. The existence of Charcot's joints illustrates the operation of nervous

influences as one of the factors in the production of this form of arthritis. I have not covered all the symptoms of vegetative disturbances in arthritis, but I should like, in summing up, to mention the fact that, generally, the arthritic belongs to the nervous type, with numerous stigmata of vegetative nervous disturbance present.

Magnus-Alsleben (18) found in animal experiments that not only the arteriole but even the capillaries of the muscle are under the direct influence of the sympathetic system. He found that resection of the sympathetic nerves changes the permeability and metabolism of the tissues involved, not through change of blood supply, but through direct influence upon the sympathetic nerves. Hajos (19), Heinrich (21), and others found, in animals sensitized with horse serum, that the anaphylactic shock could be prevented if they received X-ray treatment before they were re-injected. Sometimes the anaphylactic shock appeared after re-injection, but it was retarded or in milder form.

I am fully aware of the fact that even very carefully prepared animal experiments cannot give us full information about biologic questions; we are still dealing too much with theories. But, if working theories and animal experiments are correlated, we should be encouraged to go on with further study.

The above-mentioned results of animal experiments and clinical observations indicate certain influence of the vegetative nervous system in arthritis. When the symptoms appeared symmetrically, it was assumed that part of the higher situated vegetative nervous center was involved and X-rays were applied over this part of the body.

THERAPY

The first aim of the physician in charge of an arthritic patient is, of course, the elimination of the focal infection. Without going into detail, it might be said that there has been too much removal of teeth and tonsils and not enough attention has been paid to the intestinal tract, genital organs, and lungs. We found, in a surprisingly great number of cases, erosion of the cervix with endocervicitis as the cause in women, and, in men, chronic prostatitis. Endocrine disturbances were frequently found. If a body is in a stage of allergy, a special diet might be of great value as Rowe (22) and others have proved.

Our department has had the opportunity in the last five years to treat 1,146 patients. In 783 of these cases the referring physician prescribed treatment with some kind of physiotherapy. We regret that we were unable to do anything more with this group of patients than to carry out the doctors' orders. Another group of patients received roentgentherapy in addition, with the closest co-operation of the referring physician. This close co-operation is necessary for the reaction after X-ray therapy (Stage 1).

If the vegetative nervous system of an arthritic patient (psyche and body) seems to be in a stage of hyperexcitability and X-rays are applied to some part of the body, it is possible to assume that the vegetative nervous system of the body might pass, by reflex action, through Stage 1. Increased pain will be observed. As in foreign protein shock, the general malaise which might be present can be thus partly explained. Müller and Petersen's (24) experiments demonstrate the close connection between skin stimulation and the influence on the vegetative innervation of the other organs. Since monarthritis gonorrhoica can be so favorably influenced by X-ray therapy that some writers call it the treatment of choice, it is reasonable to assume that, provided the local infection is at the same time well taken care of, hypertrophic and atrophic arthritis could be influenced with roentgen rays.

Out of 363 patients who received X-ray treatment, 86 showed marked symptoms of

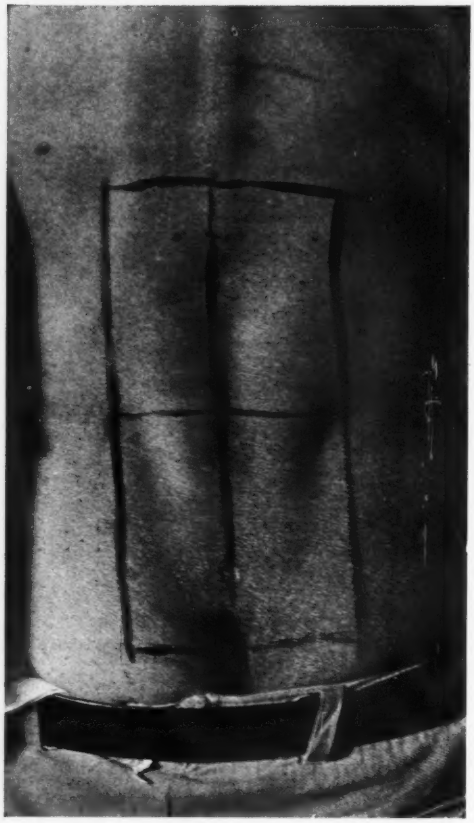

Fig. 1. For the lower extremities, two or four fields, 8 × 18 cm., aiming at the corresponding ganglia of the lower back.

vegetative nerve disturbances as described above. We gave 23 of these both local and paravertebral treatment; the remaining 63 received X-ray treatment only over the corresponding ganglia and nerves. This made them so comfortable that local treatment over the afflicted joint did not seem advisable. The coldness and clamminess of extremities, swelling of joints, and other symptoms, became less marked, and pain was greatly diminished. Only 25 per cent responded with slight improvement for a short period. The beneficial effect of such treatment lasts sometimes for quite a time. Often the treatment had to be repeatd after from six to eight weeks.

Physiotherapy, internal medication, and removal of focal infection were carried out simultaneously. The beneficial effect upon patients receiving X-ray treatment compared with the greater number who received all kinds of therapy *except* X-rays, convinces us of the superior effect of the roentgen ray over other therapeutic agents.

The technic used was short wave therapy, from 185 K.V. to 200 K.V., 0.5 mm. copper, 3 mm. aluminum, 35 cm. skin distance, wave length 0.16 Å.U., 4 milliamperes. For the lower extremities, we used two or four fields, 8 × 18 cm., aiming at the corresponding ganglia of the lower back (Fig. 1). The inclination of the tube should be 45 degrees. Each day 200 r are given each field until from 500 to 600 r have been given. For the upper extremities, one field over each side of the neck is given, including the centrum of the vegetative nervous system (Fig. 2). Each field is given 200 r daily until 500 r have been reached.

The treatment of ganglia situated higher is not always sufficient to bring about the desired result. I believe that the local treatment over the joints should be given in all cases. It is, at the present time, impossible to say whether the atrophic or the hypertrophic type shows more disturbance of the vegetative nervous system.

Out of the 363 patients treated, 65 were atrophic (18 males and 47 females); 138 were hypertrophic (45 males and 93 females). We diagnosed 160 cases roentgenologically as arthritis, either without specification of type or as belonging to the mixed type. Local treatment over the afflicted joints was given to 300 patients. For the local treatment an attempt should be made to treat the joint homogeneously with 500 r, using the same technic as mentioned previously.

After X-ray application, about 75 per cent showed increased pain lasting generally for 48 hours. For a period of from one to

two weeks after treatment, 28 per cent showed increased pain with general malaise. Opiates were needed in some cases on the first night.

Treatment can be repeated if the patient shows recurrent symptoms of vegetative nervous system disturbances. The skin temperature, taken at various intervals, can be used to determine if another X-ray treatment should be given. Increasing pain is also an indication for a repeated treatment, but at least six weeks should elapse after each X-ray series.

The reason for giving roentgen treatment in arthritis can be summarized as follows:

1. X-rays have some effect on the vegetative nervous system. After symptoms of irritation (Stage 1), a quieter condition, varying in duration (Stage 2), may be observed.
2. Roentgen rays seem to lessen anaphylactic reaction.
3. X-rays have a direct effect on lymphocytes and leukocytes and reduce general inflammation and pressure on nerve sheaths.
4. X-rays have an analgesic effect.
5. X-ray treatment produces a better blood supply in the diseased area, through its effect on the vegetative nervous system; consequently, a better tissue metabolism is established.

If the vegetative nervous system plays a certain rôle in the production of arthritis and if, as we contend, roentgentherapy has some influence on the vegetative nervous system, it is obvious that the results from such treatment cannot be expected immediately. Regeneration of tissues and their metabolism will be slow. I have frequently observed amelioration in patients even after from six to eight months have passed since treatment. These particular observations were made on patients who did not receive further treatment of any kind.

Adson and Rowntree (13), from the Mayo Clinic, have reported operative procedure on the corresponding ganglia and nerves in selected arthritic patients. I should like to suggest trying X-ray therapy first, because I am convinced that a great number of patients can be made comfortable without such drastic measures as these writers have used.

Fig. 2. For the upper extremities, one field over each side of the neck, including the centrum of the vegetative nervous system.

SUMMARY

The two most important groups of arthritis are briefly outlined.

The first publication of the use of X-ray therapy in arthritis is cited.

An attempt is made to show that the vegetative nervous system plays a certain rôle in arthritis.

The effect of X-rays on the vegetative nervous system in arthritic patients is postulated as present in two stages: Stage 1, ex-

acerbation of symptoms; Stage 2, after a certain uncomfortable period, the quiescent stage with amelioration of pain.

Cases which show symmetrical arthritic disturbances, which were treated over the corresponding ganglia and nerves in addition to the direct treatment over the afflicted joints, are described.

A statistical report, with technical comment, is furnished.

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DISCUSSION

Dr. George E. Pfahler (Philadelphia, Pa.): Osteo-arthritis is a highly chronic, obstinate, and difficult disease to treat, and in that sense it is very much like cancer. We must not merely depend upon the methods described by Dr. Langer for its treatment. It is our duty to step out of this field of specialism and be physicians and to see that the patient gets all forms of treatment that offer hope of relief. That is what the patient comes to us for; that is what the patient goes to any physician for—to get well.

When we take part in the healing process, we must co-operate with the family, or referring, physician in every way and give all the possible suggestions that will aid in curing the patient.

I think that most of us consider using the vegetative system as a factor in influencing

disease or in treating disease an impracticable procedure. We perhaps had better step out of that rôle and give attention to this subject. It is the ignoring of such phases of medicine that has stimulated all forms of irregular medicine.

I am quite sure that, to the surgeon and internist and various specialists, the idea of applying roentgen rays to the vegetative system, or even directly to the joints, for the treatment of chronic osteo-arthritis will surely seem visionary, but we have made great progress in recent years and Dr. Langer deserves credit for his persisting attention to the treatment of the vegetative system in various affections.

He is not alone. In my early years (referred to in an article which Dr. Anders, Dr. Daland, and I presented before the Pennsylvania State Medical Society, perhaps in 1906) I treated a case of osteo-arthritis that was resisting every form of treatment of which we knew at that time, and the patient experienced relief. At the present time we do not know just why, but we have a much better idea.

In the first place, we know from many experiments and from many observations on other clinical conditions that we do get a very definite result in the treatment of various kinds of inflammations, both acute and chronic. We know to-day that one of the best forms of treatment of erysipelas is roentgen-therapy properly given, and there is nothing more acute than erysipelas as an infection.

We also know that there are many chronic infections that yield to irradiation. Matsuki, working in the Roentgen Institute under Professor Holzknecht, showed that roentgen rays applied directly to a fresh wound will aid in the healing process and give a better scar and better results.

He also performed most careful experimental work on fractures in rabbits in which he broke the bones of the legs on both sides and treated one side by irradiation immediately and left the other side untreated. He showed that he got better union, with less callus formation but more solid, as a result of a single application of the roentgen rays.

Matsuki and others have also done a great deal of work to determine why we get results from treatment of inflammatory processes, studied experimentally, macroscopically, and microscopically. Therefore, we have a definite reason for applying irradiation locally to the joints as recommended by Dr. Langer and as a number of us have done. With regard to the vegetative system, it has been observed, for example, that lichen planus will yield to irradiation of the ganglia controlling the particular part affected, and we know that lichen planus is a chronic and very resistant form of skin disease.

Likewise it has been observed that treatment over the ganglia or over the suprarenal glands will have a beneficial effect in endarteritis obliterans or in erythromelalgia. Therefore, in the treatment of this condition, we are not going so far astray when we apply the rays over the affected ganglia.

Dr. Langer has referred to the fact that Dr. Pemberton, of Philadelphia, has shown that the circulatory changes occurring about an affected joint have a considerable influence on that joint. Now as if we reason back to these purely circulatory effects, when we are dealing with endarteritis obliterans, or erythromelalgia, or those vasomotor changes in which ulcers have been healed as a result of treatment purely on these centers, it is conceivable that treatment over the ganglia may affect the circulatory condition about these joints. It is, therefore, not so far afield, and it is not an isolated or wild observation.

If we work carefully and neglect nothing else in our treatment, we have added another instrument to our therapeutic armamentarium.

Dr. E. A. May (Newark, N. J.): We can obtain striking results in the treatment of arthritis, especially in the more acute conditions. Consider a case of gonorrheal arthritis with great swelling, tremendous pain, and temperature: give that patient an X-ray treatment over the joint. The pain will have lessened within an hour or two, and within one or two days the swelling will have subsided. Acute infectious arthritis sometimes responds so well as to make surgical procedure unnecessary.

Chronic arthritis also responds well—of

course not so quickly as in the acute case, but it is very gratifying to note that patients do not complain of pain, and, in cases in which the knee is affected, to see them walking again.

We combine X-rays with diathermy, which has a very good effect. I do not think I give as much radiation as Dr. Langer does, if I understand him correctly. The more acute the case is, the less radiation I give, 15 or 20 per cent of an erythema dose. In more chronic cases I give more, repeating the dose when necessary—every week or two weeks. After the series is finished, I wait four weeks before resuming treatments.

Dr. Langer (closing): It is very difficult to come before any Society, offering a new point of view and technic. One is always received with a certain skepticism. It is a new field, but I was glad to hear, at the International meeting in Paris, that our French confrères were interested in it. They have worked empirically for some time on that same problem. Zimmern, Cottenot, Desplats, Gouin, and others belong to this group.

We are going on with this kind of technic and we hope (and that is the reason I brought this paper before you) to get co-operation from others. Try it in some cases, please, which do not make progress under other therapeutic procedures. I am sure you will find that this new technic will give you satisfaction in selected cases.

ROENTGEN-RAY EXPLORATION (DIAGNOSIS) OF PELVIC VISCERA WITH AID OF IODIZED OIL[1]

By JOSEPH JOHNS EISENBERG, M.D., Milwaukee, Wisconsin

SINCE 1927, we have been using iodized oil as an aid in visualizing the uterine cavity and fallopian tubes. Up to 1928, we used lipiodol and iodipin, but for the last three years we have applied brom-

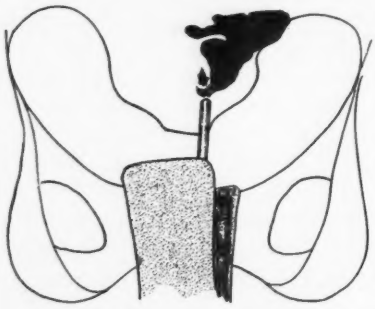

Fig. 1-*A*. Diagram

Fig. 1-*B*. A normal uterus holds from 3 to 5 c.c. of oil. The uterus shown here has been injected with 5 c.c. of oil, but is not entirely filled, evidencing a defect in the left body of the uterus. The roentgenogram should show the uterus entirely filled.

inol, a 37 per cent solution of bromine in olive oil. Primarily, injection was undertaken solely to visualize the physiologic action of the tubes. That the physiologic function of the tubes is a necessary factor in the transportation of the ovum has been assumed by physiologists. As far as is known, the functions of the tubes or their actions have never been observed during laparotomy, perhaps due to the general anesthesia which causes paralysis of the muscles of the tubes.

In 1922, Sicard and Forestier (6)

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

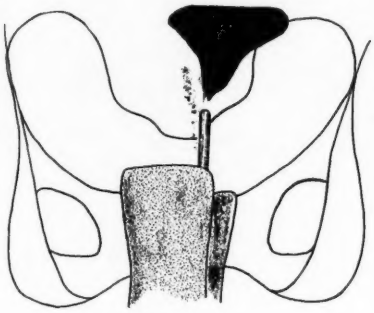

Fig. 2-*A*. Diagram

Fig. 2-*B*. The same case, showing the uterus normal, holding 8 c.c. of oil.

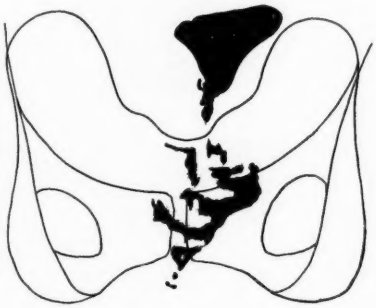

Fig. 3-*A*. Diagram.

Fig. 3-*B*. The uterus is allowed to empty and the oil can be seen dripping through the cervix into the vaginal vault.

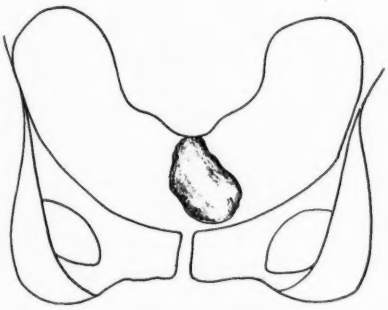

Fig. 4-*A*. Diagram.

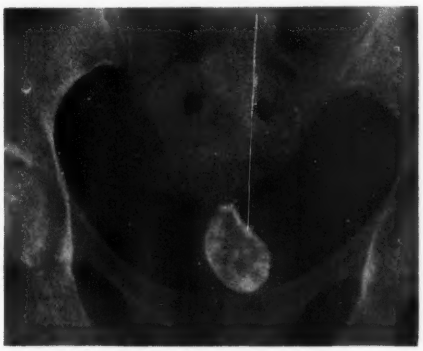

Fig. 4-*B*. The same case. The uterus is entirely empty. The oil is visible on a pad in the vagina.

Fig. 5-*B*. The same case. The uterus has been injected with 10 c.c. of oil, showing both uterine sphincters. The left isthmus is plainly visible, with the ampulla, which is beginning to widen, containing pearls of oil.

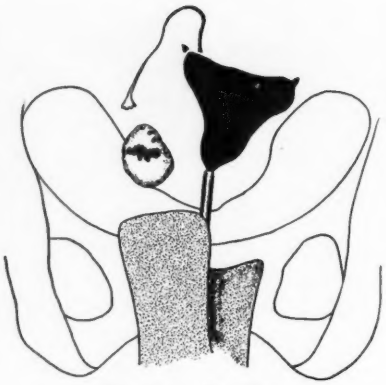

Fig. 5-*A*. Diagram.

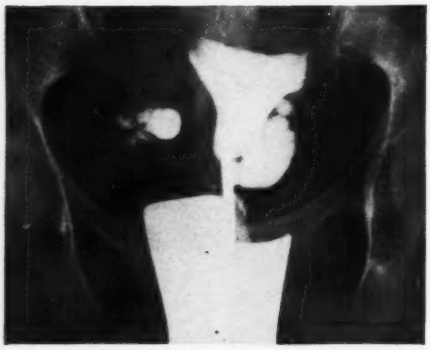

Fig. 6-*B*. The same case. The uterus and adnexa have been injected with 20 c.c. of oil, which demonstrates a clumped left tube and a large hydrosalpinx encroaching on the right cervico-uterine body. The mass is also behind the posterior uterine body.

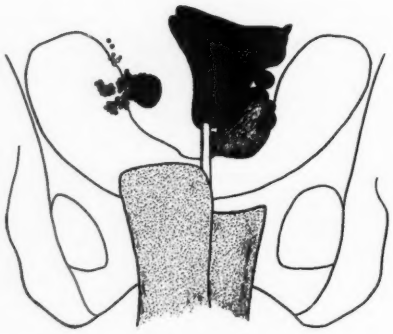

Fig. 6-*A*. Diagram.

Fig. 7-*B*. The same case. The uterus is empty 24 hours after the injection, and the vagina shows no traces. Note the huge hydrosalpinx.

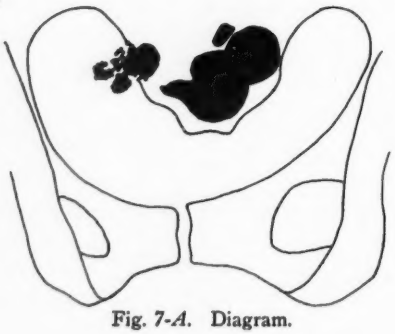

Fig. 7-*A*. Diagram.

Fig. 8-*A*. Diagram.

Fig. 8-*B*. The same case, which was followed for seven months. The diagnosis is right utero-ovarian cyst. This illustration shows the necessity of following cases injected with iodized oil for diagnostic purposes.

brought forth the use of lipiodol as a contrast medium. Corner and Seckinger (1), in 1923, were able to prove peristalsis of the tubes in animals by registering on films the movements of the tubes in monkeys and hogs. Dyroff (2), in 1925, succeeded in demonstrating peristaltic movements in the human with X-rays. Kok (3) has carried out numerous experiments on living animals in order to study the physiology of the muscles of the fallopian tubes. He summarizes the results of his work as follows:

1. Peristalsis is the normal physiologic movement of the fallopian tubes.

2. Peristalsis is directed from the fimbria to the uterus.

3. The presence of a foreign body in the ampulla produces antiperistalsis.

Rubin (5), in 1926, described tubal peristalsis in women.

At the beginning of our work, all injections of iodized oil into the uterine cavity were observed and studied under the fluoroscopic screen. X-ray plates were then taken after from five to fifteen minutes. These were re-checked by films made within one-half hour, one hour, three hours, and twenty-four hours. Necessary cases were roentgenographed and studied at various intervals for varying periods, some as long as seven months (Figs. 1-*A* through 8-*B*). By careful observation, in introducing the iodized oil into the uterine cavity, and fluoroscopically watching it as it enters the tubes, one sees the peristalsis and contractions in from five to fifteen minutes.

A series of cases was studied fluoroscopically and then roentgenographed for observation of the physiologic function. At first, it was difficult to determine whether or not peristalsis was present. With increased experience, a strong contraction of the isthmic portion (Figs. 9-*A* and 9-*B*) and a rhythmic contraction of the ampulla were visualized (Figs. 10-*A* and 10-*B*). The ampullar contractions, at times, became worm-like and tortuous (Figs. 11-*A* through 13-*B*), due to antiperistalsis as a result of the foreign body injected. In but few cases could one observe a normal physiologic function, namely, a true peristalsis, from the fimbria toward the uterus (Figs. 14-*A* through 16-*B*). The most common sites in which stenosis was observed, due either to adhesions or sealing of the tubes, were at the isthmus and fimbriated ends (Figs. 17-*A* through 18-*B*). The first part of the tube corresponding to the isthmus was, as a rule, thin, extending downward, and was usually from 1 to 2.5 inches in length (Figs. 19-*A* and 19-*B*). The contractions at this part were usually the strongest. The part corresponding to the ampulla extended downward

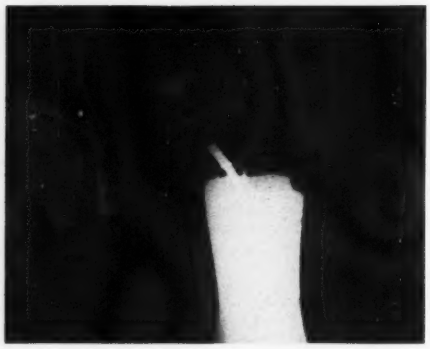

Fig. 9-*B*. Visible peristalsis and a strong contraction of the isthmic portion of the tube are seen.

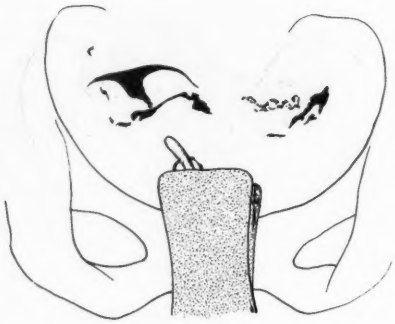

Fig. 9-*A*. Diagram.

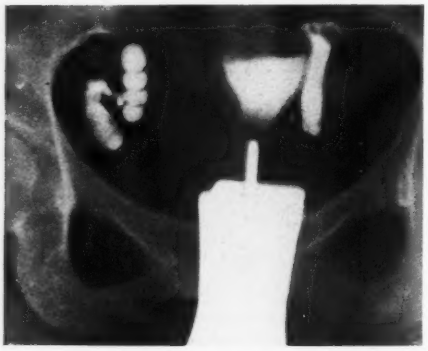

Fig. 10-*B*. The left tube shows a rhythmic contraction. Note four beadings with fimbria encircling the left ovary. This is a false peristalsis. The right tube shows no peristalsis.

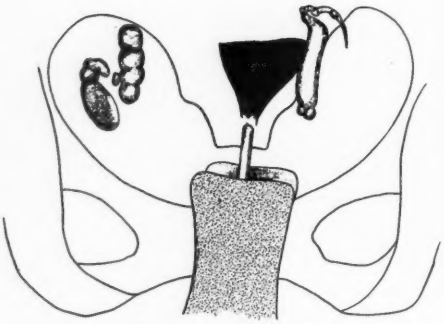

Fig. 10-*A* Diagram.

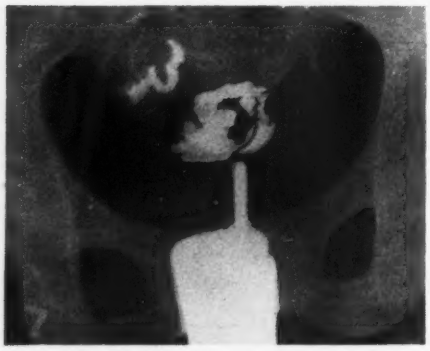

Fig. 11-*B*. Corkscrew and worm-like contraction of the left tube. During fluoroscopy, the uterus showed a sudden contraction, which may be interpreted as peristalsis.

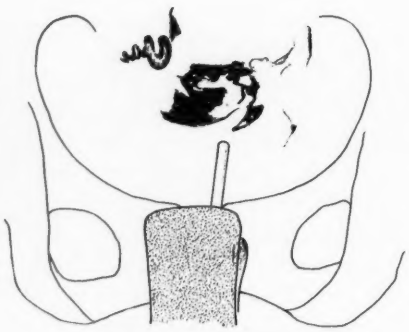

Fig. 11-*A*. Diagram.

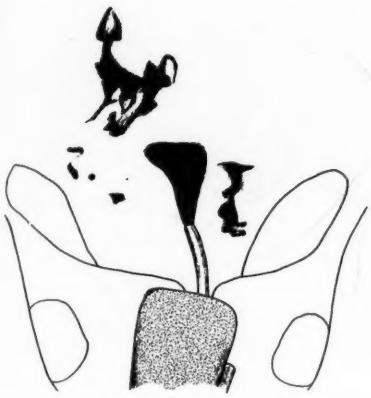

Fig. 12-*A*. Diagram.

Fig. 12-*B*. A tortuous left tube, extending high into the abdomen. The right tube is prolapsed into the pelvis.

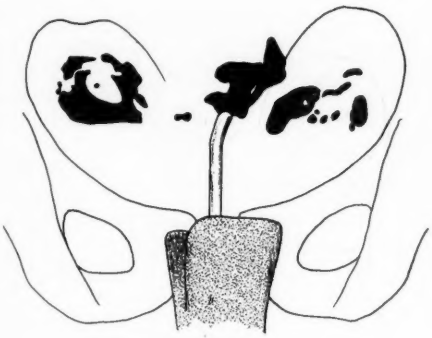

Fig. 13-*A*. Diagram.

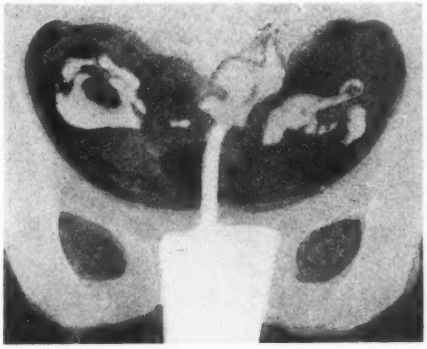

Fig. 13-*B*. An illustration of the shape and position the normal tubes may assume. Note the spill of both fimbriæ.

Fig. 14-*A*. Diagram.

Fig. 14-*B*. True peristalsis from the fimbria toward the uterus. This is best seen under the fluoroscopic screen by emptying the uterus of oil after the tubes are filled.

Fig. 15-*B*. True peristalsis. Note the characteristic beadings. Both fimbriæ encircle the ovaries.

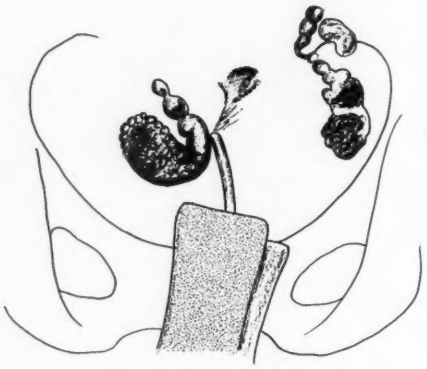

Fig. 15-*A*. Diagram.

Fig. 16-*B*. True peristalsis of both tubes with the uterus filled with oil.

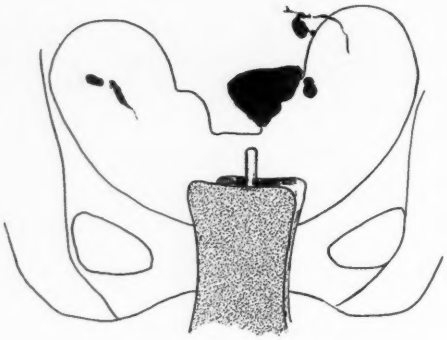

Fig. 16-*A*. Diagram.

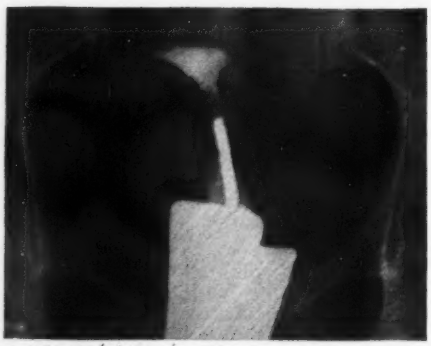

Fig. 17-*B*. Constriction of both isthmic portions of the tubes is seen, due to adhesions.

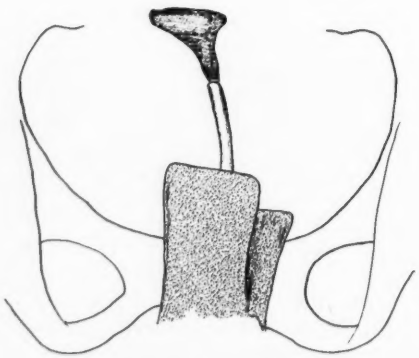

Fig. 17-*A*. Diagram.

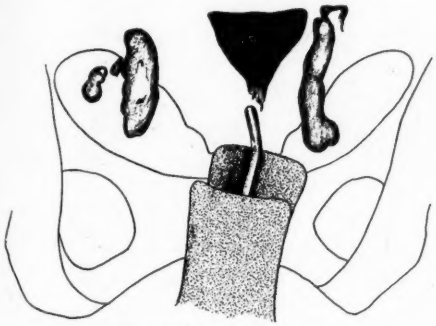

Fig. 18-*A*. Diagram.

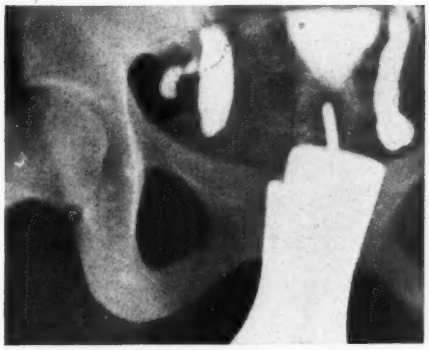

Fig. 18-*B*. Showing the site of constriction at the fimbria, with sacculated tubes.

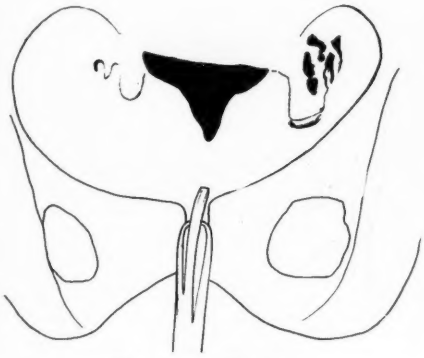

Fig. 19-*A*. Diagram.

Fig. 19-*B*. Note the outlines of both isthmuses. They are thin, from 1.5 to 2.5 inches long, usually extending downward.

and outward and was nearly always the most widened portion (Figs. 20-*A* and 20-*B*). Motion in the ampulla could almost always be seen; it at times assumed a good many different positions. The fimbria appeared fan-shaped, encircling the surface corresponding to the ovary (Figs. 21-*A* through 22-*B*).

The consistency and size of the uterus, with or without tumor masses, can, as a rule, be determined by the usual bimanual examination; however, a considerable number of growths may escape detection. One cannot always determine a growth by palpation, whether it is part of the uterus or a tumor mass of the adnexa. Upon the X-ray plate, a filling defect within the uterus is usually found to be due to uterine myomas (Figs 23-*A* and 23-*B*). Irregular outlines of the uterine cavity are, as a rule, due to extra-uterine tumors (Figs. 24-*A* and 24-*B*) which produce pressure upon the uterine wall. In markedly obese patients, the outline of the uterus can be plainly seen on the X-ray plate with the aid of iodized oil, though bimanual examination does not reveal whether the mass so palpated is a part of the uterus, tube, or ovary (Figs. 22-*A*, 22-*B*, and 25-*A* through 27-*B*).

Stein (7) stated that fibroid tumors cannot be diagnosed by X-rays with the use of only iodized oil. Our study corroborates his findings. During the last three months we have been using iodized oil combined

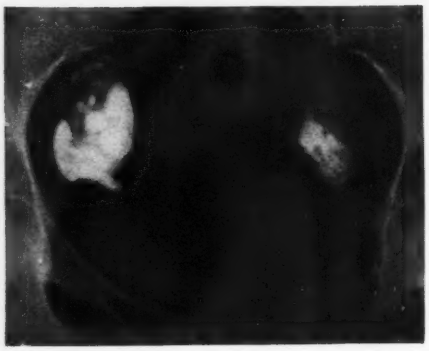

Fig. 20-*B*. The ampulla of the tubes is usually dilated and the most widened portions, as a rule, extend downward into the pelvis.

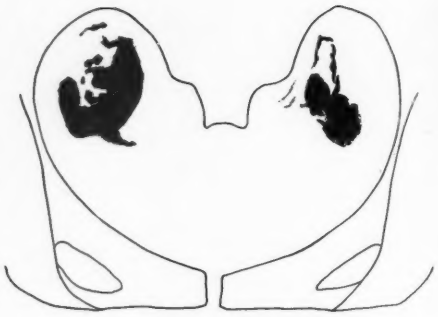

Fig. 20-*A*. Diagram.

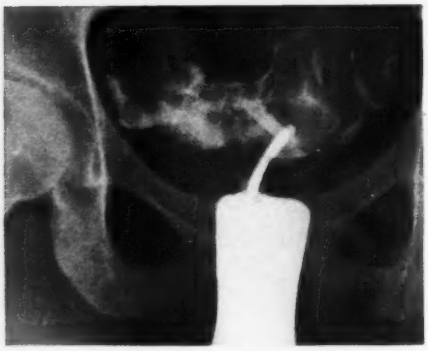

Fig. 21-*B*. Both fimbriæ are plainly seen encircling the surface corresponding to the ovaries.

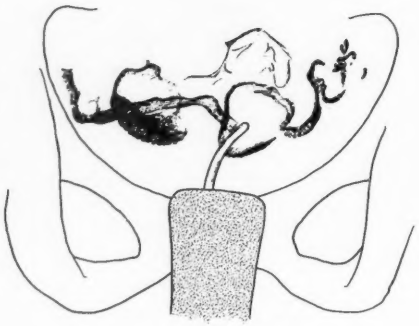

Fig. 21-*A*. Diagram.

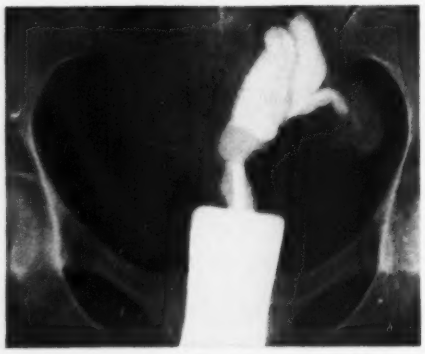

Fig. 22-*B*. The fan-shaped right fimbria, encircling the surface of the ovary.

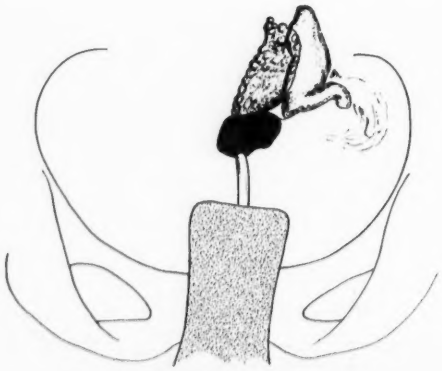

Fig. 22-*A*. Diagram.

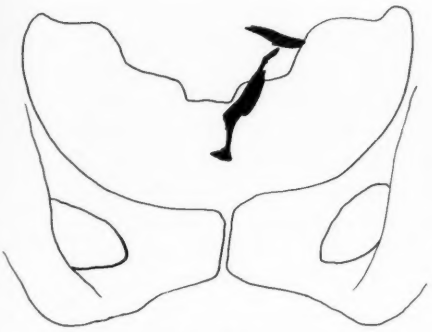

Fig. 23-*A*. Diagram.

Fig. 23-*B*. The uterus has failed to fill, due to myomas.

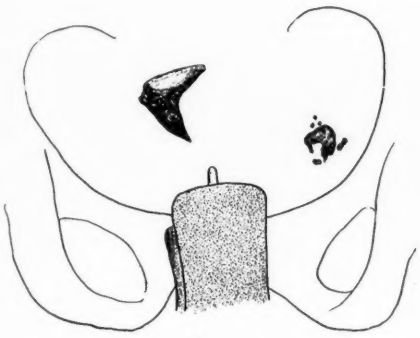

Fig. 24-*A*. Diagram.

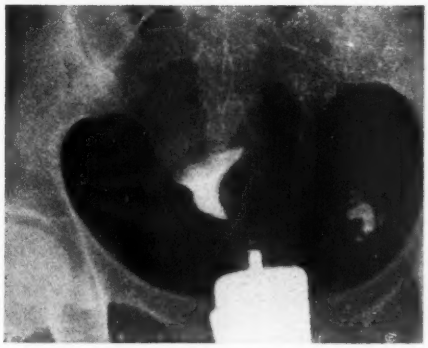

Fig. 24-*B*. Deformity of the right cervical uterine body is present, due to a large ovarian cyst. The right tube is visible in the pelvis.

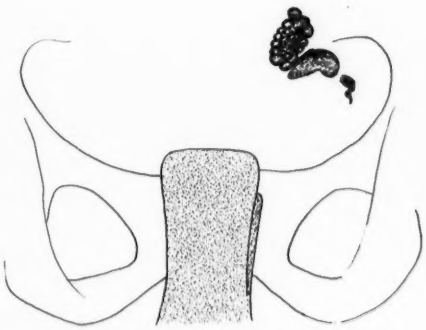

Fig. 25-*A*. Diagram.

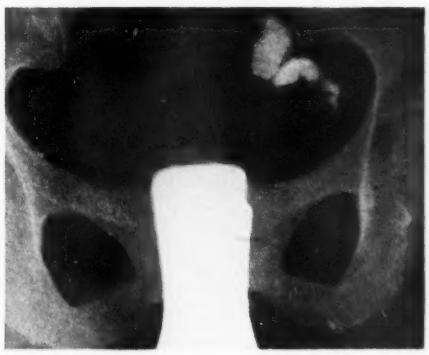

Fig. 25-*B*. The right uterus and tube, injected with 5 c.c. of oil.

with the method of pneumoperitoneum, which, we believe, is a more satisfactory and ideal way of localizing tumors of the uterus and adnexa. Either iodized oil or pneumoperitoneum, used separately, has its own advantages: one is indicated where the other is not and *vice versa.*

At first, especial care was taken not to use intra-uterine injections of iodized oil if any cervical discharge was present. The same rule was applied to cases in which there was any suspicion of the presence of endometritis or salpingitis. Prior to 1922, iodized oil was used orally and by injection for its therapeutic effect. Two years ago, it occurred to us that if iodized oil could be used as a diagnostic and therapeutic adjuvant in cases of bronchiectasis and tuberculosis of the lungs without any ill effects or complications, why, then, could it not be used for intra-uterine insufflation in cases of endometritis and salpingitis (non-gonorrheal)? It has, therefore, been used during the last few years, being slowly applied and carefully observed, in all cases with cervical discharges of known endometritis. Slides were examined to rule out gonorrheal infection. No ill effects were complained of nor did complications follow. As a matter of fact, in a good percentage of the cases the discharge subsided partly or almost entirely. Finally, it was introduced in cases of known salpingitis, caused either as a result of post-abortive conditions or post-deliveries. These cases were carefully watched and re-examined, and no ill effects were produced in any.

Iodized oil has never been used by us in establishing a diagnosis of pregnancy or in cases of known carcinoma. Miller and Martinez (4) have shown that abortion is likely to follow introduction of oil into a pregnant uterus. In cases of carcinoma, there is a possibility of distributing cancer cells.

In the cases studied we have the primarily sterile as well as patients who have previously given birth to infants and later become sterile, due either to post-abortions or adhesions of the tubes following delivery. Others have become sterile, probably due to an attack of appendicitis, either before or soon after marriage. A good many of these cases have become pregnant in from three to nine months. These are the cases in which the use of intra-uterine and tubal insufflation is of pathognomonic value. A patient with a bicornate uterus (Figs. 13-*A*, 13-*B*, and 28-*A* through 29-*B*), who had been subjected to a carbon dioxide pneumoperitoneum three years previously, was delivered 16 months after insufflation with iodized oil.

The cases were ambulatory. All injections were given in the clinic and no enemas or narcotics were necessary. The patient is put on a flat Bucky X-ray table. A weak lysol solution is used to cleanse the labia and vagina. A bivalve speculum is inserted, after which the cervix is painted with mercurochrome. A single tenaculum holds the cervix and a cannula is inserted into the cervical canal. Dilatation of the cervix is not necessary. A couple of small, moist pieces of gauze are inserted about and around the cervix. The syringe is attached to the cannula, the palm of the hand which holds the syringe being the best manometer. Usually, at first 5 c.c. are injected, more if necessary. We have never used more than 20 c.c. of iodized oil.

In 100 private cases studied for a period of four years, in which iodized oil was used, there have been no ill effects or complications produced. Included in these are a good number which were operated upon. Among them are a number of cases of known endometritis and hydrosalpingitis injected for diagnostic and therapeutic purposes. In endometritis with symptoms of discharge, slides were made to rule out active gonorrhea. All cases of known endometritis and salpingitis, after being injected with the iodized oil, evidenced an increased amount

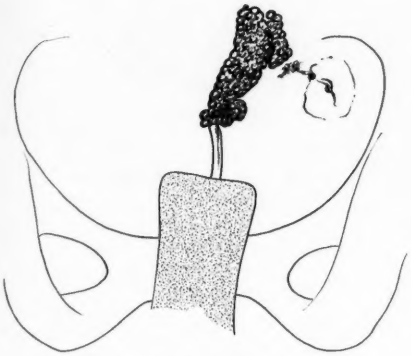

Fig. 26-*A*. Diagram.

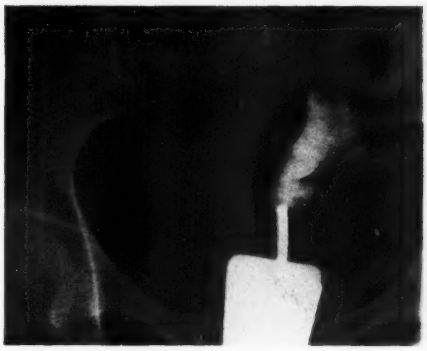

Fig. 26-*B*. The uterus, filled with 12 c.c. of oil, showing the right and left tubes behind the posterior wall of the uterus.

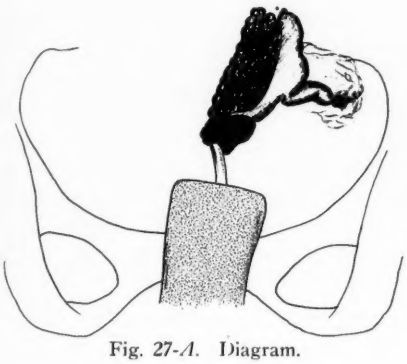

Fig. 27-*A*. Diagram.

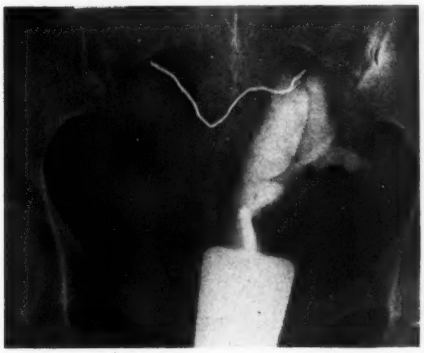

Fig. 27-*B*. The uterus and tubes filled with 20 c.c. of oil, showing plainly the outline of the uterus. Both tubes are adherent to and behind the uterus.

Fig. 28-*A*. Diagram.

Fig. 28-*B*. The right cornu filled with oil. The right tube shows a spill. The left tube is sacculated, with a visible spill of fimbriæ.

Fig. 29-*B*. Both uterine cornua are filled with oil, plainly showing the bicornate uterus.

Fig. 29-*A*. Diagram.

of discharge, followed by a gradual decrease, and almost entire subsidence in from two to three months. A normal menstrual cycle was restored in many.

X-ray interpretation should be made by a competent radiologist. Cases injected with iodized oil should be studied for at least two or three months with X-ray plates. Many times abnormal findings, which are not visible at first, may be detected at a later period (Figs. 1-*A* through 8-*B*).

There should be more co-operation between the gynecologist and radiologist. The clinical findings in borderline cases should be corroborated by X-ray interpretation.

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DISCUSSION

Dr. L. R. Sante (St. Louis, Mo.): We have used iodized oil in pelvic radiography, especially in conjunction with pneumoperitoneum. Having first secured proper inflation, you produce pneumoperitoneum which can be followed by the injection of iodized oil. By the use of both methods, you can secure even further information than by either method alone.

We have endeavored to use iodized oil injections in determining the condition of the uterus, for instance, in certain therapy cases, and have found it of great value. Efforts to outline the extent of carcinomatous involvement have not been so successful.

Every once in a while a patient is sent for treatment, perhaps of a supposed submucous fibroid, on account of bleeding. We treat the patient, but without a satisfactory result. We are not able to tell just exactly what is going on a little higher up. In those cases, the injection of iodized oil may remove all doubt and sometimes lead to correction of an erroneous diagnosis.

Iodized oil injection with X-ray examination should be utilized for diagnosis for all lesions of the uterus above the cervix before radiation therapy is undertaken. We have

even gone so far as to attempt to use iodized oil to indicate the contour of a carcinomatously involved cervix, before treating the growth, but this is not such a satisfactory procedure because the very density of the oil overshadows the underlying irregularities of the cervix. The method is to place the patient on a table in a tilted position, and to plug the vagina with a rather large rubber bulb during the introduction of the oil. This, however, has not proven so satisfactory.

DR. EISENBERG (closing): We have attempted to show and prove the value of the use of iodized oil as an aid in visualizing the uterine cavity and fallopian tubes. Besides being used roentgenologically for diagnostic procedures, iodized oil has proven itself therapeutically beneficial.

We believe that the effects of iodized oil for the period that we have used it should be concluded as entirely harmless. Iodized oil should be incorporated as an aid in radiology. Its use should be welcomed by the gynecologist, surgeon, and general practitioner.

The comments in the discussion made by Dr. Sante are well taken. We have lately combined pneumoperitoneum with iodized oil as an aid in localizing gross tumor masses, such as fibroids and cysts.

EXPERIMENTAL CLINICAL RESEARCH WORK WITH X-RAY VOLTAGES ABOVE 500,000

A PRELIMINARY STATEMENT[1]

By ALBERT SOILAND, M.D., D.M.R.E., LOS ANGELES

DURING the Summer of 1930, the writer was invited by Dr. R. A. Millikan and Dr. C. C. Lauritsen, of the California Institute of Technology, to inspect the high voltage X-ray tube installation at the Institute. Dr. Lauritsen, who had been experimenting with the 1,000,000-volt transformer set at the Institute, had succeeded in building a large X-ray tube of glass through which 5 ma. of current operated successfully at 750,000 volts. This equipment, which was designed for physical research purposes only, had been in successful operation for many months. It occurred to Dr. Lauritsen that the radiation produced by this tube might have some biologic effect which could be utilized in the treatment of disease. Because the writer was much impressed by Dr. Lauritsen's achievement, he suggested, after consultations with Dr. Millikan and Dr. Lauritsen, that he be permitted to put the tube to clinical tests. After investigating further and advising with the writer's own clinical associates, Dr. Costolow and Dr. Meland, Dr. Millikan and Dr. Lauritsen agreed, with the consent of the Board of Trustees of the California Institute of Technology, that we be allowed to bring some of our own patients to the Institute for experimental clinical tests.

The experimental treatment schedule was begun in October, 1930. The first patient treated was a middle-aged man with an inoperable adenocarcinoma of the rectum, a patient of Dr. C. Edgerton Carter.[2] The electrical factors for this first experimental treatment were: voltage, 600,000; milliamperes on the tube, 4; filters, 6 mm. of steel and 1 cm. of felt; skin-target distance, 50 tuberculosis. Spondylitis with lipping, which centimeters. Those present at the dedication of the Lauritsen tube were Dr. Millikan, Dr. Lauritsen, Dr. Carter, and Dr. Soiland.

After this experimental beginning, we selected a small number of our own patients who had inoperable and hopelessly advanced

[1]Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

[2]As an item of interest, it may be stated that this patient to-day, two years after his first treatment, has gained 20 pounds in weight, has no pain, and attends to his daily duties. The proctologist who has examined him recently says there is but a vestige of the old lesion present.

carcinoma of various organs—patients who already had been under treatment and had become radiation-fast with our standard X-ray equipment. We carried on these experiments over a number of months and became convinced that the high voltage X-ray beam, as delivered by the Lauritsen tube, presented tangible effects which we had not always been able to produce with our own standard equipment.

Assisted by Dr. Lauritsen and his research associates at the Institute, we prescribed a tentative set-up of 550 K.V., filtered through 6 mm. of steel, with 4 ma. on the tube, and a 50 cm. skin-target distance. With this arrangement, 900 r will produce a pronounced skin erythema, if given in one treatment, at the rate of 20 r per minute. The result of the preliminary work was encouraging enough to warrant the establishment of a better organized unit for continued clinical research.

About this time, Mr. W. K. Kellogg, of Battle Creek, Michigan, who visited the Institute, became sufficiently interested in the work to donate funds for the building of a separate high voltage laboratory, now completed.

Dr. Lauritsen has more recently constructed a tube with a capacity of 1,000,000 volts potential, and further research work is going on in the new Kellogg Laboratory with the following factors: 750 K.V., 4 ma., 6 mm. steel and 1 mm. Al filter, 70 cm. skin-target distance. This department is under the immediate charge of Dr. Seeley G. Mudd, who has become greatly interested in the work and devotes his time and energy to the furtherance of the clinical experimentation. Dr. Mudd is assisted by Dr. Clyde K. Emery and by my clinical associates, Dr. William E. Costolow and Dr. Orville N. Meland, as collaborators.

The entire work is under the supervision of an advisory medical board of seven California clinicians, of which the writer is the radiologic member. This board rightly feels that no evaluation of results can be made until the permanency of the effects has been established by due process of time.

Every patient submitted to treatment is carefully examined by a competent group of clinicians connected with one of the leading hospitals. Only such patients are accepted as are found to be unfit for surgery and resistant to the usual type of X-ray treatment available in the ordinary cancer clinic or general hospital.

More than two hundred patients have now been submitted to radiation, and no startling variations from the former routine are noted. Skin erythema and tanning occur in approximately the same ratio as with lower voltages, indicating that there is little or no difference in biologic skin reaction, irrespective of voltage used, once the erythema skin unit dose has been established. Whether or not this ratio holds true below the skin surface and beyond the vision is problematical. This solution may well rest until sufficient time has elapsed to establish permanently cell and tissue reactions, both latent and delayed, from radiation of every wave length or voltage. Radiation sickness also occurs; likewise, the usual systemic reactions with varying neuroses. All in all, no gross specific differences have been elicited. Clinical reactions are a little more difficult to interpret. It appears to the writer that patients who reach a point of stasis in their clinical response to X-ray treatment at 200 K.V. usually improve when they are submitted to 500 K.V. or over. Whether this is due to the higher voltages or to more homogeneous radiation with increased depth dosage, or whether there is a biologic radiation difference, the future will have to demonstrate.

Two full years have elapsed during which this therapeutic work at the California Institute of Technology has been carried on at a voltage of 550,000, and 4 ma. in the tube high line, and the other factors already quoted. At the time of this writing, treat-

ment work has been started in the new Kellogg Laboratory, with a tube voltage of 750,000, a little higher filtration, and a little longer skin-target distance. The Institute intends to prosecute steadily an analytic experimental treatment research campaign.

To the clinical radiologist, the outcome of this research work will be of momentous importance. If we recall that, for the past ten years, there has been no appreciable change in therapeutic apparatus, the best obtainable up to the present being a possible peak of 200,000 volts, to soar into a voltage four times higher presents problems which require most serious and earnest consideration. Apparatus of this extreme voltage is limited to institutions in which the best engineering skill in its construction and assembly is available, with physicists in control of operations, so that all electrical and X-ray dangers are reduced to the lowest possible minimum.

Should it develop later that this super-short wave X-ray therapy is superior to anything we have had in the past, it will be necessary for the treatment to be made more universally available. To accomplish this we must consider certain very essential factors which will be briefly touched on here.

1. The cost of equipment and accessories, which would vary from thirty to fifty thousand dollars, according to style and size of equipment, with its housing requisites. Such a formidable installation would, in the writer's opinion, be prohibitive for the average radiologist even to consider. It would be more feasible for centralized institutions, geographically selected to serve their respective communities—preferably the larger hospitals having suitable clinical and physical facilities.

2. The maintenance and operation of such an X-ray center.

It would be impossible for the average physician or radiologist to operate such an institution himself. Electrical engineers and qualified physicists would be required to maintain the efficient operation of a super-high voltage plant with its powerful transformer and intricate control panel, its tube with connecting vacuum pumps and pressure gauges, its ionization chamber and spectrograph, and all the other requisites necessary to keep the radiologist continually informed of the exact output of the tube, in order that the required dosage might be accurately calibrated.

3. Dangers, both electrical and X-ray, to the patient and to the operator.

Naturally, every known precaution is constantly necessary in order that anyone coming into the vicinity of the X-ray tube or the high tension electrical line may be amply protected. The proper correlation and execution of these factors must be obtained so that the patient may derive the greatest benefits from these, as yet, experimental and potentially dangerous methods of treatment.

It already appears practical, both from an electrical and an engineering angle, to manufacture X-ray equipment and tubes up to an almost unlimited voltage. It behooves us, therefore, to make haste slowly and, first, to be sure of our ground with an already known voltage before we essay a flight into the unknown, for there we may reach a point beyond the safety limits of the normal cell where unlimited and irreparable damage may result.

It is now well established in all scientific circles that radiation plus surgery (or radiation alone) are the best weapons so far developed to destroy cancer cells. If, as may not be improbable, time demonstrates that the shorter wave lengths from the higher voltages such as those under discussion, bring results which are superior, it then becomes mandatory for us to carry forward this work that the service may be extended and made available throughout the medical world to all who may need it.

Before embarking on this new venture on a pretentious scale, good judgment requires

that we keep an orderly balance and observe and tabulate most accurately results from the experimental work already under way.

If we are to agree with some of the physicists who have studied radiation therapy and believe that X-rays from any and all voltages have the same biologic effect, then we must resort to still higher voltage to obtain the penetration needed for the treatment of deep-seated malignancies. Again, those of us who have the courage of our convictions, and believe that we yet have a great many things to learn about short wave radiation, must needs maintain our hopes and expectations that every new departure into the fields of higher electronic energy will prove of greater benefit to an afflicted human race and eventually render more conquerable that universal, dread disease—cancer.

In closing, the writer desires to emphasize the fact that the contents of this article are merely expressions of his own opinion and belief, and not an official report from the California Institute of Technology.

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STUDIES OF THE EFFECT OF ROENTGEN RAYS ON THE HEALING OF WOUNDS

II. HISTOLOGICAL CHANGES IN SKIN WOUNDS IN RATS FOLLOWING POST-OPERATIVE IRRADIATION[1]

By ERNST A. POHLE, M.D., PH.D., Professor of Radiology, and
GORTON RITCHIE, M.D., Assistant Professor of Pathology
University of Wisconsin Medical School, MADISON, WISCONSIN

IN a previous communication[2] we reported the results of our experiments dealing with the behavior of skin wounds in rats under pre- and post-operative irradiation. It appeared that exposure to a dose of 1,000 r given in one sitting from 1 to 30 days before the incision did not influence the healing process perceptibly. Exposure to a dose of 1,000 r in one sitting immediately, 24, and 48 hours, respectively, after the incision retarded the healing process, particularly in the 24-hour group, but did not interfere with the final formation of a smooth scar. In view of these findings it seemed advisable to investigate further the histological changes found in incisions exposed to roentgen rays. The technic used was identically the same as described in the first paper, with one fundamental exception. While in our first series histological findings were recorded only 7 days after the cutting or after complete healing of the wounds, in this second group specimens were taken at daily intervals of from 1 to 9 days after the incision. A minor change was the use of metaphen as a disinfectant. Since in the first series no difference could be detected in the reactions produced by the two wave lengths chosen, only one (100 K.V., 2.0 mm. Al λ eff. = 0.34 Å. transmitted through 2.0 mm. Al) was employed in this study. Thirty-four rats were exposed immediately, 26 rats 24 hours, and 18 rats 48 hours after cutting, making a total of 78 animals in this report.

[1]Received for publication April 7, 1932
[2]RADIOLOGY, April, 1931, XVI, 445.

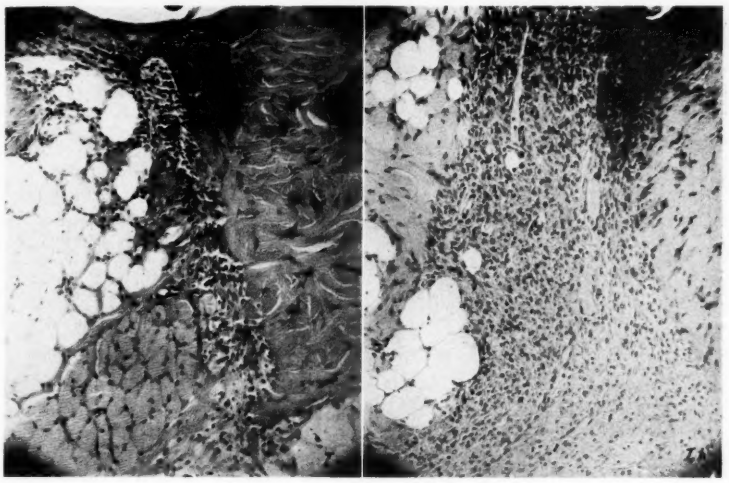
PROTOCOLS OF EXPERIMENTS

A. Exposed Immediately after Incision (34 Rats)

Rats Nos. 75, 76, 77, 78, killed 1 day after incision.

Rats Nos. 71, 72, 73, 74, killed 2 days after incision.

In these two groups no difference could be noted between the healing in treated and untreated parts. Almost no cellular activity was seen in the sections.



Figs. 1-*A* and 1-*B*. Rat No. 3. Sections across wound. Irradiated immediately after cutting; section taken 7 days later. *A (left),* treated part; *B (right),* untreated part. Note great difference in amount of newly formed fibrous tissue, with a proportional difference in cellular activity along the margins of the wound.

Rats Nos. 31, 32, 33, 34, 51, 52, 54, 55, killed 3 days after incision.—In Rat No. 33 there was fairly well-advanced healing in the untreated part, but inactivity in the treated part. In Rat No. 52 the control part of the wound showed almost complete healing, while the treated part lagged somewhat. A slight difference was noted in Rat No. 54, the untreated part being further advanced in healing.

Rats Nos. 25, 28, 53, 56, killed 4 days after incision.—In Rat No. 25 there appeared a marked difference between the two halves, the untreated part being considerably in advance of the treated part. This is also true of rats Nos. 53 and 56.

Rats Nos. 35, 36, 37, 38, killed 6 days after incision.—In all of these wounds there was a great difference in fibroblastic activity in favor of the control halves.

Rats Nos. 1, 2, 3, 4, 5, 6, 26, 27, 29, 30, killed 7 days after incision.—These sections all showed in different degrees an advance in healing in the untreated portions.

B. Exposed 24 Hours after Incision (26 Rats)

Rats Nos. 57, 60, killed 2 days after incision.—No difference between the treated and untreated parts could be observed.

Rats Nos. 19, 22, 58, 61, killed 3 days after incision.—No marked difference could be seen in Nos. 19, 58, and 61. The wound of Rat No. 22 was infected.

Rats Nos. 20, 23, 59, 62, killed 4 days after incision.—In Rat No. 20 no difference could be noted. In No. 23 the epithelium had healed over in both halves, but the connective tissue underneath was inactive in the treated part, practically healed in the untreated half. A slight difference in favor of

the untreated part could be seen in Rat No. 59, but none in No. 62.

Rats Nos. 21, 24, 67, 68, 69, 70, killed 4 days after incision.—In all these wounds except No. 70 there was a decided difference in favor of the control parts. In No. 70 the condition was reversed (possibly a technical error).

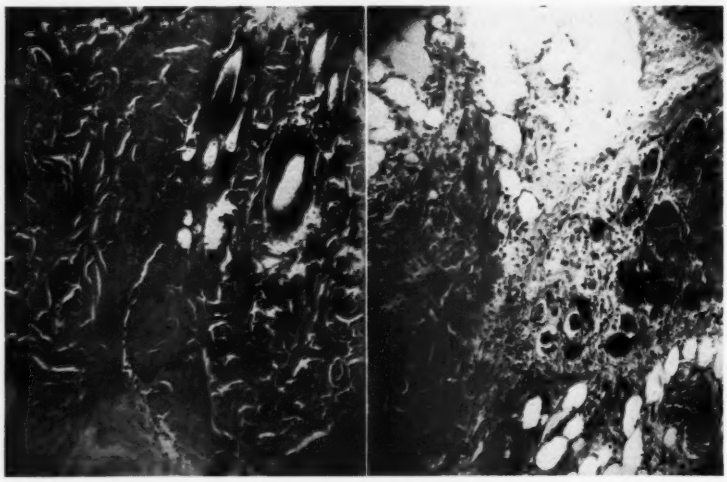
Rats Nos. 39, 40, 41, 42, killed 7 days after incision.—The usual difference, varying in degree, prevailed in these wounds. In No. 39 the tissue was distorted, making exact evaluation difficult, but the other three were clear-cut in result.

Rats Nos. 7, 8, 9, 10, 11, 12, killed 8 days after incision.—Healing in these was more advanced in the control halves of the wounds.

C. Exposed 48 Hours after Incision

Rats Nos. 63, 64, 65, 66, killed 4 days after incision.—No difference between the two halves of the wounds here, except in No. 64, in which there was slight advantage in favor of the *treated* part.

Rats Nos. 17, 18, 43, 44, 45, 46, killed 7 days after incision.—In rats Nos. 17 and 18, the fibroblasts appeared to grow up from the deeper parts of the wound, with little activity superficially. In the control portions, growth was straight across the wound. In the rest of these a slight difference was noted in favor of the untreated halves of the wounds.



Figs. 2-*A* and 2-*B*. Rat No. 20. Treated 24 hours after cutting; sections taken 4 days after cutting. *A (left)*, treated part; *B (right)*, untreated part. Note lack of healing in *A*, in spite of better approximation, and active fibroblastic proliferation in *B*.

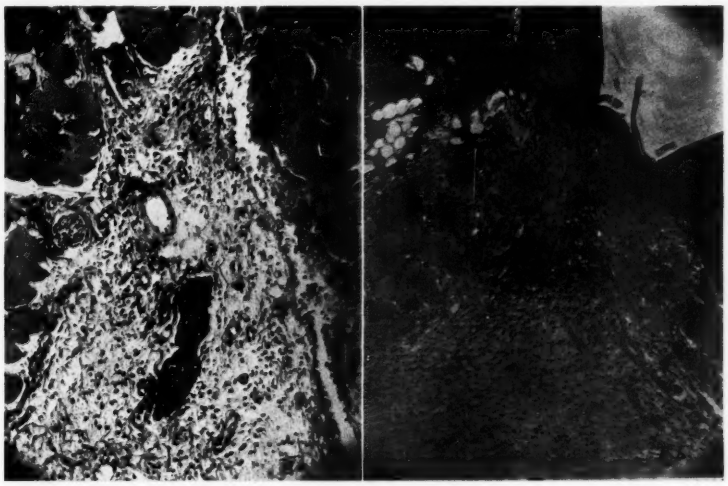
Rats Nos. 15, 16, 47, 48, 49, 50, killed 8 days after incision.—In Rat No. 16, though there was infection, a distinct difference could be noted between the treated and untreated parts, the untreated part being further advanced in healing. In No. 48, the directional difference could be noted as in Nos. 17 and 18. In No. 49, the healing of the incision was greatly advanced in the control, while only a slight difference of the same type was noted in Nos. 47 and 50.

Rats Nos. 13, 14, killed 9 days after incision.—Little difference was seen in these

TABLE I

	1 day[3]			2 days			3 days			4 days			5 days			6 days			7 days			8 days			9 days		
C-E Interval	+	—	T.[4]	+	—	T.	+	—	T.	+	—	T.	+	—	T.	+	—	T.	+	—	T.	+	—	T.	+	—	T.
0	0	4	4	0	4	4	4	5	9	3	1	4	—	—	—	4	0	4	2	2	4	—	—	—	—	—	—
24 hr.	—	—	—	0	2	2	0	3	3	2	2	4	2	0	2	—	—	—	3	0	3	6	0	6	—	—	—
48 hr.	—	—	—	—	—	—	—	—	—	0	3	3	—	—	—	—	—	—	2	4	6	2	3	5	1	2	3

[3]Interval between incision and killing of rat.
[4]Total number.



Figs. 3-*A* and 3-*B*. Rat No. 67. Treated 24 hours after cutting; sections taken 5 days after cutting. *A (left)*, treated part; *B (right)*, untreated part. The wound slants downward and to the right in *A*. Note lack of marginal fibroblast formation as contrasted with that in *B*.

specimens between treated and untreated halves of the wounds.

In order to provide a comprehensive study of the results obtained, the data are tabulated in Chart I. Representative sections were chosen from different groups for illustration (Figs. 1-6).

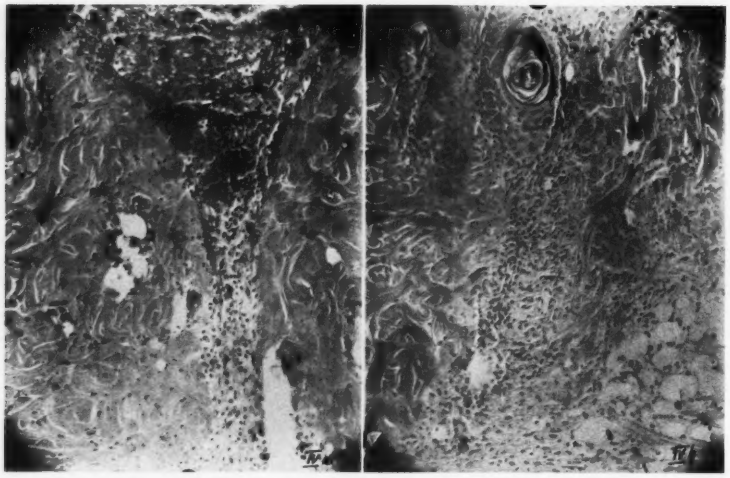
DISCUSSION OF RESULTS

In examining the wounds microscopically, we have found that there are striking variations from the normal in the healing of wounds treated by X-rays in the dose used. In an unirradiated incision, active repair begins very soon after cutting, and definite fibroblast formation can be noted by the end of 48 hours at the latest. In the treated portion of a wound, however, there is a definite retardation of this process. The edges of the wound appear inactive and sluggish. Fibroblasts, if noted at all, are seen relatively late, and then in reduced numbers. In addition to this there is distinct irregularity of growth, and the newly formed cells tend to be atypical.

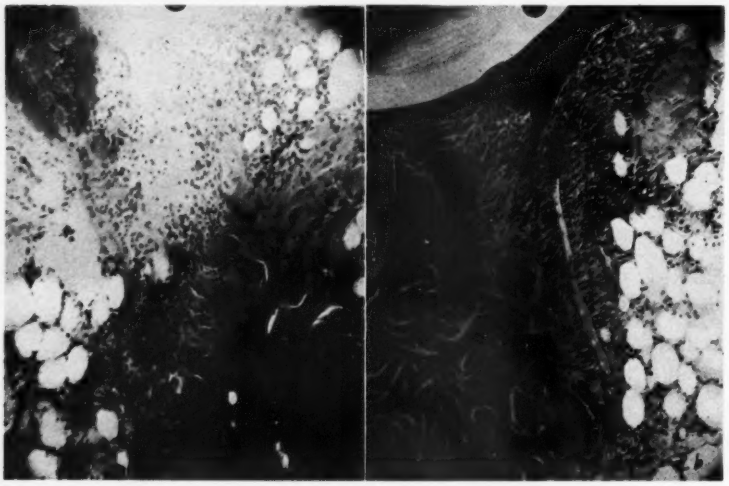
The changes described vary considerably with the different variations in the time elements. The most marked change was noted in those animals in which irradiation took place 24 hours after cutting, and the difference between irradiated and control tissues began to be evident from three to four days after the cutting, but seemed most ap-

parent about seven or eight days after the wound was made.

In certain animals there was no appreciable difference between the exposed and unexposed parts of the wounds. A qualitative evaluation of the effects of the treatment in the different groups is difficult, and its value becomes extremely doubtful when we consider the variable reaction to the same treatment in different individuals. We have endeavored, therefore, to express our results quantitatively, counting as positive

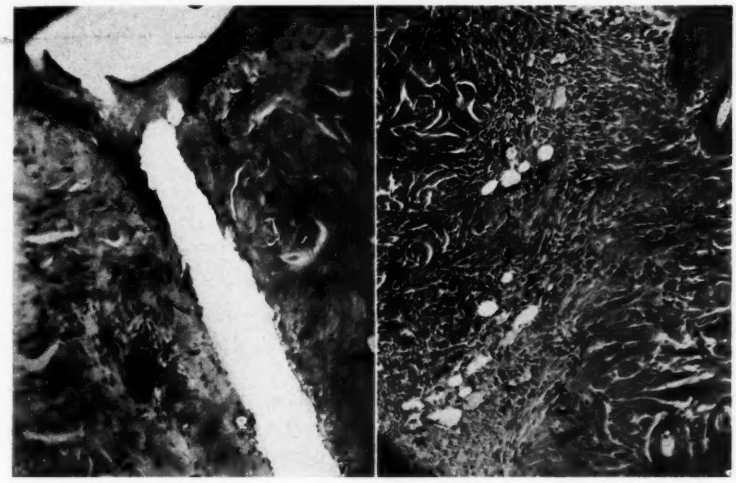


Figs. 4-*A* and 4-*B*. Rat No. 10. Treated 24 hours after cutting; sections taken 8 days after cutting. *A (left)*, treated part; *B (right)*, untreated part. Differences noted as in Figures 3-*A* and 3-*B*.



Figs. 5-*A* and 5-*B*. Rat No. 17. Treated 48 hours after cutting; sections taken 7 days after cutting. *A (left)*, treated part; *B (right)*, untreated part. Note difference in direction of fibroblast growth. In *A*, growth is toward surface from the deeper parts; in *B*, straight across the wound.

those wounds in which there could be no doubt as to the difference in the two halves. This evaluation is easily expressed, then, when one states the proportion of positive results in each group (Table I).



Figs. 6-*A* and 6-*B*. Rat No. 49. Treated 48 hours after cutting; sections taken 8 days after cutting. *A (left),* treated part; *B (right),* untreated part. Contrast obvious. Note also the healing over of epithelium, with almost entire inactivity of underlying connective tissue.

A study of Table I shows that the most constant positive results are seen in wounds treated 24 hours after cutting, while those which were treated with no C-E (cutting-exposure) interval or after 48 hours showed a definitely higher proportion of negative findings.

Three points of especial interest may be emphasized here. In the first place, it was found that in different animals there were distinct variations in reaction, though the animals had been treated exactly alike, within limits of human error. This merely illustrates the well-known principle, forgotten by many writers, of individual variation in laboratory animals as well as in human patients.

Secondly, the irradiation seems to have less effect on the growth of epithelium than on that of the underlying connective tissue, so that in many cases there is a complete restitution of the epithelial covering while the deeper part of the wound is far from being completely healed. This phenomenon may account for some of the conflicting opinions as to clinical results; that is, superficial gross appearances are deceptive, and one may think that an irradiated wound is healing rapidly, whereas microscopic examination of the underlying tissues would lead to the opposite conclusion.

Lastly, it is apparent that in many cases the upper layers of the connective tissue have suffered most, so that there was active connective tissue proliferation in the deeper part of a wound while the superficial parts still showed a well-marked inactivity. In view of the fact that there is little loss of radiant energy in the first centimeter of tissue, it seems improbable that this observation could be explained on the basis of the absorption law.

SUMMARY

1. Seventy-eight rats were exposed to roentgen rays (100 K.V., 2 mm. Al) immediately, 24 hours, and 48 hours following incisions in the skin of the back. Half of each wound was irradiated following the cutting and the other half was protected. Sections were made of specimens taken at daily intervals from one to nine days after the incisions. Twelve animals were discarded on account of infection of the wounds.

2. Delay in healing was most constantly observed in wounds treated 24 hours after cutting. Histologically this became evident from three to four days after the cutting, but seemed most apparent about seven or eight days following incision. The irradiation seems to have less effect on the epithelium than on underlying connective tissue.

DIAGNOSIS AND ROENTGENOLOGIC EVIDENCE IN SPONDYLOLISTHESIS[1]

By HENRY W. MEYERDING, M.D.,
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SUBLUXATION of the spine, spondylolisthesis, formerly considered a rare deformity and reported by obstetricians as occurring more often among women, is now more frequently recognized, and is found to be common among men. This is the result of more careful analysis of clinical observations and improved technic of roentgenologic examination of patients complaining of pain low in the back. Of the 125 cases reported previous to 1900, only about 5 per cent were males. Of the patients coming to the Mayo Clinic, 71 per cent were males.

Even though a clinical diagnosis of spondylolisthesis is made, the roentgenogram is indispensable in proving its presence. The roentgenologist is called on to determine the site of the subluxation, its extent, the presence of predisposing factors (such as congenital deformities), to find evidence of fracture, and to rule out complications. With modern equipment and technic the roentgenograms, properly interpreted, often permit solution of the etiologic factors: trauma and congenital defects.

I believe that this deformity is not generally recognized by the medical profession; the condition had been diagnosed in less than 10 per cent of the cases I have observed. In 1921 at the Mayo Clinic, a diagnosis had been made in only two cases; in 1930 it was made in 41 cases (0.054 per cent), and, in the first nine months of 1931, in 46 cases (0.092 per cent). The average diagnosis in more than 500,000 cases was 0.023 per cent, which is probably still too low.

The patients with spondylolisthesis who are usually seen in the clinic are farmers, laborers, and their wives (64 per cent). The average duration of symptoms had been 8.75 years. The ages were from 11 to 80 years; the average age was 40 years, and 80 per cent of the patients were between 20 and 60 years. Males constituted 71 per cent, and females 29 per cent, in a series of 207 patients observed at the Clinic.

Patients with spondylolisthesis may not have symptoms and may not be aware of the presence of deformity; 9 per cent of the cases in the Clinic were discovered incidentally. Acute spondylolisthesis of traumatic origin may produce immediate and total disability, accompanied by excruciating pain and apparent paralysis. Symptoms may

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

occur long after the injury and subluxation; they may be aggravated by stress and strain. Vague pain in the legs was the symptom which led to discovery of spondylolisthesis in 5 per cent of cases; pain in the legs, thighs, and hips, associated with backache, in 36 per cent. Chronic backache, however, was the principal complaint in 50 per cent. Thus, 86 per cent of these patients with spondylolisthesis complained of backache or sacro-iliac pain with or without pain in the legs. Weakness was manifest in 5 per cent and numbness in 10 per cent of the cases. In many cases, roentgenograms of the spinal column had been interpreted as negative, and, on inquiry, it was found that only anteroposterior views had been made. The subjective symptoms might easily be construed as those of "railroad spine," "traumatic spine," or "neurosis," unless careful inspection of the back and palpation suggested the possibility of subluxation and led to proper roentgenologic examination. If the individual appears to be otherwise healthy and is gaining in weight, pain low in the back, producing partial disability which is relieved by rest and is aggravated by work, is often suspected of being due to malingering. I believe that many so-called sacro-iliac strains are in reality injuries to the lumbosacral articulation in which there is no demonstrable clinical or roentgenologic lesion.

The spinal column may appear normal or grossly deformed, depending on the situation and degree of subluxation. It may not be possible to discern displacements graded 1 either on inspection or on palpation, but, as deformity graded 2 is approached, a definite depression of the lumbar spinous process is observed. The fifth lumbar process and the sacrum become more prominent, and the erector spinæ stand out and may be spastic to varying degrees. If the thumb is brought down along the spinous processes, it will sink in a lumbar lordosis in a depression, and come to rest on a ledge made by

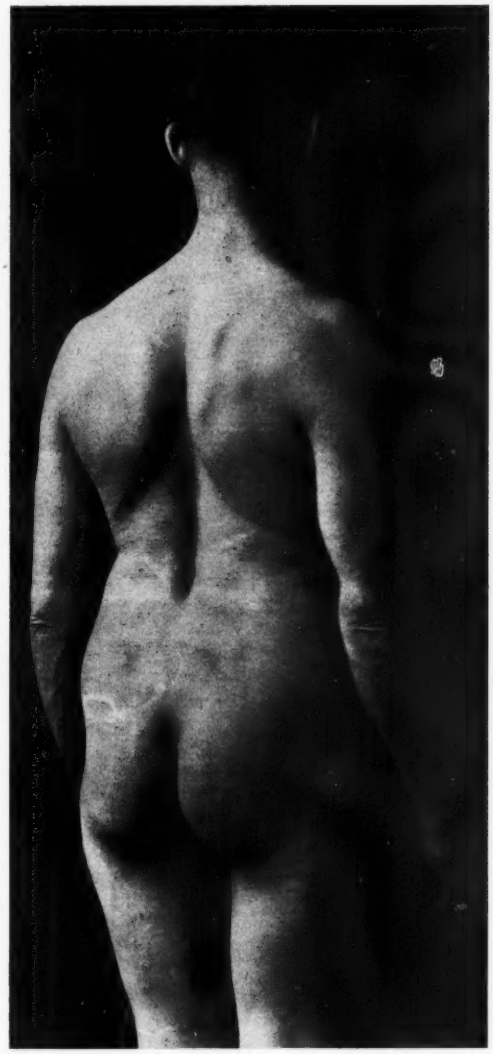

Fig. 1. Spondylolisthesis of the fifth lumbar vertebra. Lordosis, deep shadow, prominent sacrum, short torso, and broad pelvis may be noted.

the fifth spinous process and the sacrum (Fig. 1). If light strikes the back from the side, it casts a dark shadow in the groove between the muscles in the lumbar lordosis, whereas the high light appears on the prominence of the sacrum. I speak of the "depression" and the "prominence" in describing this.

Spinal curvature and tilting of the spinal

column are not uncommon. As the subluxation increases, the entire torso becomes altered. In deformities graded 3 and 4, the torso is definitely shortened, marked lordosis appears, and the ribs sink into the pelvis pelvis, due to the fifth lumbar vertebra slipping forward and downward.

Occupations which require stooping and lifting and the carrying of heavy burdens are unbearable to some patients. The gait

Fig. 2. Traumatic spondylolisthesis (graded 2) of the fifth lumbar vertebra on the sacrum and lateral spondylolisthesis of the fourth on the fifth lumbar vertebra. The injury had been received 30 years previous to the examination. *A (left),* anteroposterior view; *B (right),* lateral view.

with a deep crease forming in the loin and across a short and often prominent abdomen. The depression is marked, the sacrum stands out prominently, and, on percussion and deep palpation, spasm of muscle and tenderness of the lumbosacral region are noted. The pelvis appears broadened, with bulging of the flesh about the ilia. Motion of the spinal column becomes limited; lateral motion may be fairly normal, and posterior and especially anterior motion are sharply limited. Some patients fear to bend backward because of feeling a "sharp stabbing pain" or "something giving way." In the presence of such marked deformity, low abdominal palpation may disclose a bony mass in the median line. Proctoscopic or rectal palpation discloses narrowing of the may vary from normal to guarded, or even waddling. Jarring and jolting of the spinal column, except in cases of acute spondylolisthesis, are never so painful as in cases of berculosis. Spondylitis with lipping, which occurs in about 20 per cent of cases, may account for some of the complaints.

Neurologic signs are usually absent unless congenital defects or severe trauma affect the cord; approximately 86 per cent of these defects occur between the fifth lumbar vertebra and the sacrum, at which level complete paraplegia does not take place. Saddle areas of paresthesia are common. Inspection and palpation, therefore, vary with the degree of subluxation. The clinical diagnosis is usually made in severe cases.

Modern roentgenologic examinations have

shown great frequency of congenital anomalies of the fifth lumbar vertebra and the first sacral vertebra. No doubt many anomalies, which are seldom the cause of symptoms, still escape detection. Under long-continued strain or pregnancy, sudden, severe injury may prove too great a test, and these weakened structures, with imperfect muscular and ligamentous support, may be incapable of maintaining their normal relationship. Lordosis occurs, the angle of the lumbosacral joint becomes more perpendicular, and the inferior articular processes of the fifth vertebra are no longer kept from slipping over the superior articular processes, especially when there is separation of the neural arch by fracture or defect.

Congenital defects may be present a lifetime without the patient's knowledge. Even subluxation of the spinal column may exist to a marked degree without symptoms; nevertheless, I believe that trauma is often the exciting cause of pain and disability. When trauma focuses the attention on the lower part of the back and the roentgenogram proves the presence of subluxation, it

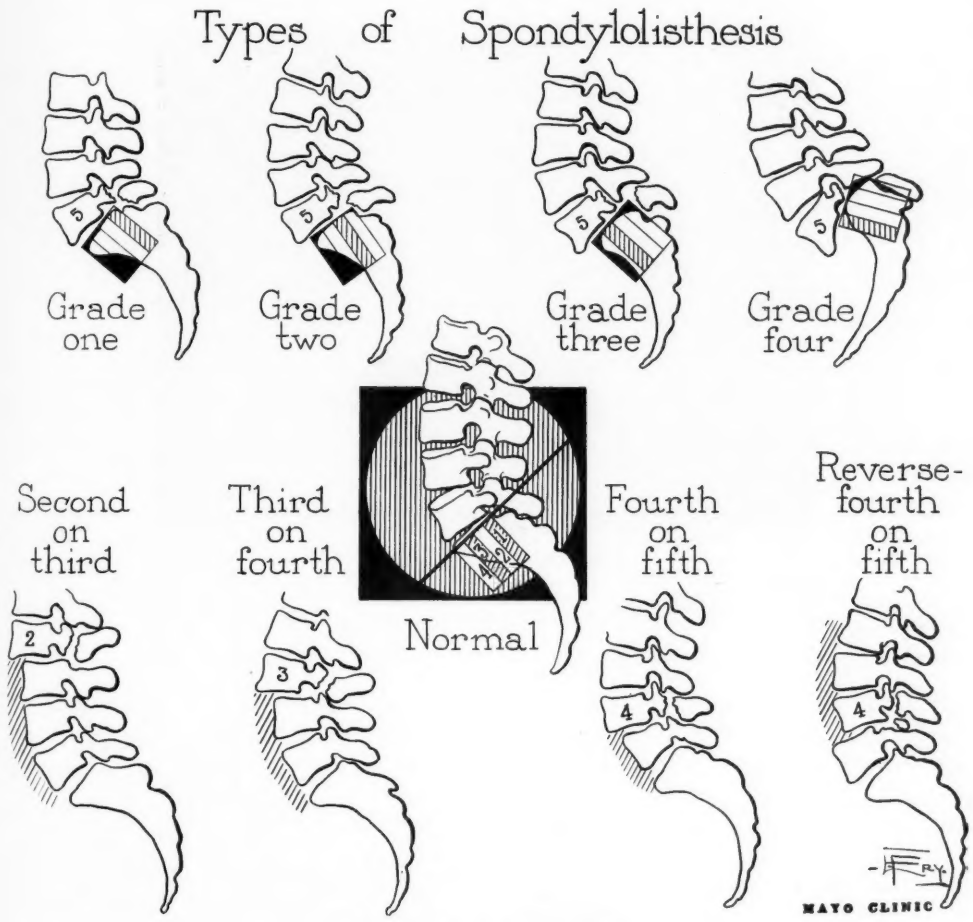

Fig. 3. Gradation of displacements.

does not prove that the spondylolisthesis was due to the injury, although the symptoms of pain in the back, previously absent, may be present (Figs. 2-*A* and 2-*B*). A diagnosis of traumatic spondylolisthesis may be made, but it may be difficult to prove it unless roentgenograms previous to injury are available, or unless corroboratory evidence of fracture, callus, and so forth, are present. With the employment of modern technic, anomalies, fractures, degree of spondylolisthesis, and lateral displacements may be studied from various angles by means of anteroposterior, lateral, and stereoscopic roentgenograms, and the factors involved in etiology may be considered with relation to the history or physical state. Thus the expert roentgenologist is in the most favored position to solve the problems confronting the medical profession in regard to spondylolisthesis. In reviewing anteroposterior roentgenograms, some degree of superimposed fifth lumbar vertebra on the sacrum was shown in almost 70 per cent of the proved cases of spondylolisthesis. Lateral views are most important, as the diagnosis in Grade 1 is often impossible from the anteroposterior views alone. As the displacement increases to the second, third, and fourth stages, the lumbar spinous process becomes shortened, and the fifth lumbar vertebra is superimposed on the sacrum, as shown by increased density, often clearly outlined. Only four lumbar vertebræ may be visible above the sacrum and there may be lateral displacement of the spinal column on the sacrum. The ribs appear so close to the pelvis as to seem to rest on it. The spinous process and transverse processes of the lower lumbar vertebræ may be tilted upward. Spina bifida occulta is observed in about 35 per cent of roentgenograms.

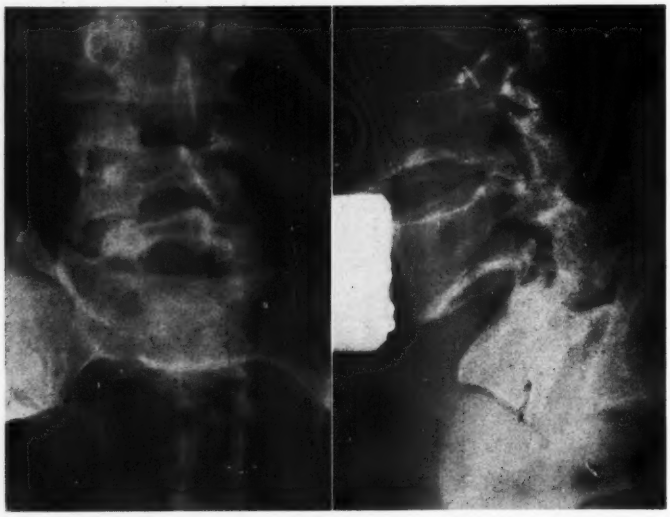

Fig. 4. Spondylolisthesis (graded 3) of the fifth lumbar vertebra on the sacrum, with spina bifida occulta. The patient was a laborer, aged 25 years, with chronic backache, leg ache, and weakness. *A (left)*, anterolateral view; *B (right)*, lateral view, with lipping of the sacral promontory.

Lateral roentgenograms permit the grading of displacement. If the fifth lumbar vertebra slips forward less than a fourth the distance across the lumbosacral joint, it is

graded 1; if it slips less than half-way across, it is graded 2; if less than three-fourths, it is graded 3, and if more than three-fourths, it is graded 4 (Fig. 3). The angle of the lumbosacral joint varies from

the patients averaged 8.75 years, the roentgenograms were sometimes faded or damaged, and it was not always possible to determine the exact nature of the anomaly. I have used the term "separation of the neural

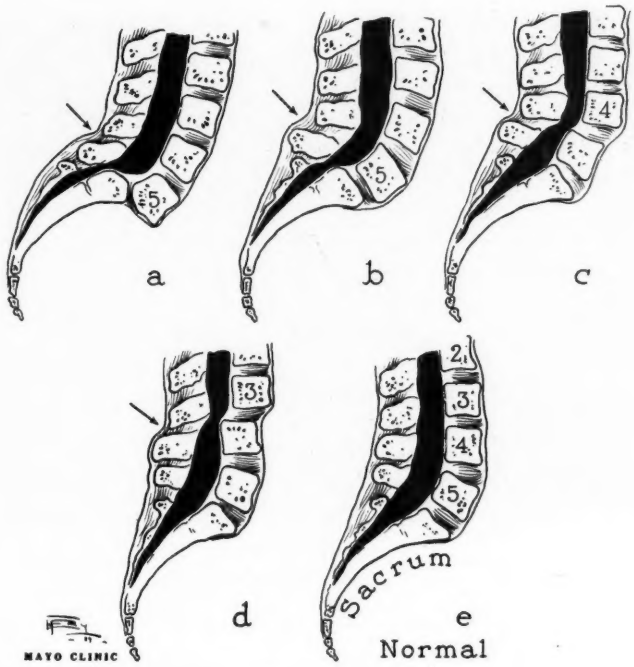

Fig. 5. The effect of spondylolisthesis on the spinal canal, sagittal section. *A*, involving the lumbosacral joint, graded 3; *B*, involving the lumbosacral joint, graded 1; *C*, involving the fourth and fifth lumbar vertebræ, graded 1; *D*, involving the third and fourth lumbar vertebræ, graded 2, and *E*, normal section through lumbosacral area. Arrows indicate depression.

normal to perpendicular and the fifth lumbar vertebra may lie entirely displaced in front of the sacrum, with its articular surface facing the anterior pelvic border of the sacrum. The fourth lumbar vertebra forces its way to rest on the sacrum.

Thus the degree of displacement and the angle of the lumbosacral joint vary amazingly. Rudimentary vertebræ or a sixth lumbar vertebra may be present. The condition of the neural arch and isthmus, whether elongated, fractured, or separated by congenital defect, may be noted. As the complaints of

arch" broadly to cover any defect, whether of traumatic or congenital origin. In a series of 48 more recent lateral roentgenograms, separation of the neural arch was discernible in 70 per cent of the cases (Figs. 4-*A* and 4-*B*). The sacral promontory appeared lipped in 15 per cent of cases and sheared off, with the sacral articulating surface semicircular in 15 per cent. The size and shape of the fifth lumbar vertebra varied greatly; in 54 per cent, the vertebra often appeared smaller and flattened behind. The shape and width of the lumbosacral joint, as

well as the angle, presented many variations. In 40 per cent, the posterior edge of the body of the fifth lumbar vertebra appeared to be driven downward and forward to the sacrum, the intervertebral disk apparently was forced ahead, widely separating the lumbosacral articulation anteriorly. Minor variations were shown (Fig. 5). The spinal canal in these cases becomes distorted and narrowed, and, in tracing it, one may gauge the presence of lesser displacements of the vertebra more readily than from a study of the anterior border of the lumbar spinous processes and sacrum.

Instead of a forward displacement of the spinal column and torso, a backward slipping may take place, producing reverse spondylolisthesis (Figs. 6-*A* and 6-*B*). In four of these cases I have observed the deformity was marked in none; the displacement, however, was obvious in lateral roentgenograms, and a small gibbus was palpable. The anteroposterior roentgenograms would be of little value in the diagnosis of reverse spondylolisthesis.

I have found the most frequent form of spondylolisthesis to be the slipping forward of the fifth lumbar vertebra on the sacrum. This occurred in 86 per cent of the cases. The fourth lumbar vertebra slipped forward on the fifth lumbar vertebra in 11 per cent (Figs. 7-*A* and 7-*B*), the third lumbar vertebra on the fourth lumbar vertebra in 1 per cent, and reverse spondylolisthesis occurred in 2 per cent.

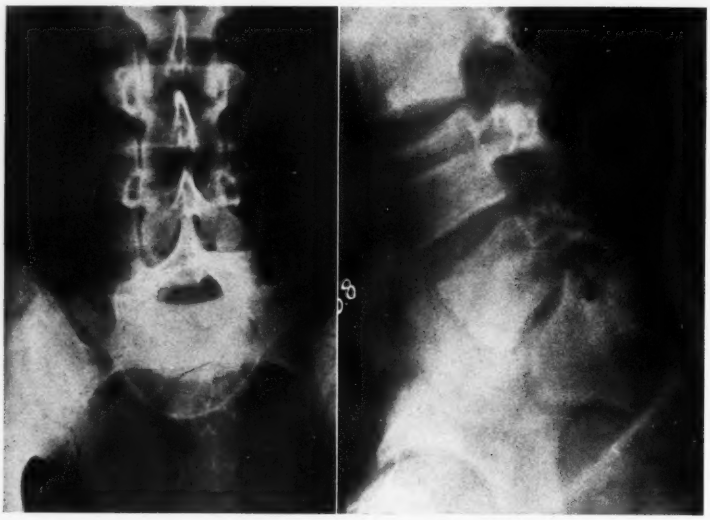

Fig. 6. Spondylolisthesis (graded 4) of the fifth lumbar vertebra on the sacrum. The patient, a laborer, aged 20 years, complained of stiffness and a lump on the back which had been diagnosed tuberculosis of the spinal column. *A (left),* anteroposterior view of the fourth lumbar vertebra above the sacrum; the fifth is superimposed on the sacrum and clearly outlined on an area of increased density. *B (right),* lateral view of rounded articular surface of the sacrum and wedge-shaped fifth lumbar vertebra.

CASE REPORTS

Case 1. A girl, aged 19 years, complained of backache following an automobile accident 14 months previous to examination. She recalled having later lifted something and injuring her back, and pain developed in her legs, associated with chronic backache.

Strapping of her back had afforded some relief, and she wore a belt with some benefit. Tonsillectomy had been performed.

Examination disclosed shortening of the torso, lordosis, and prominence of the fifth

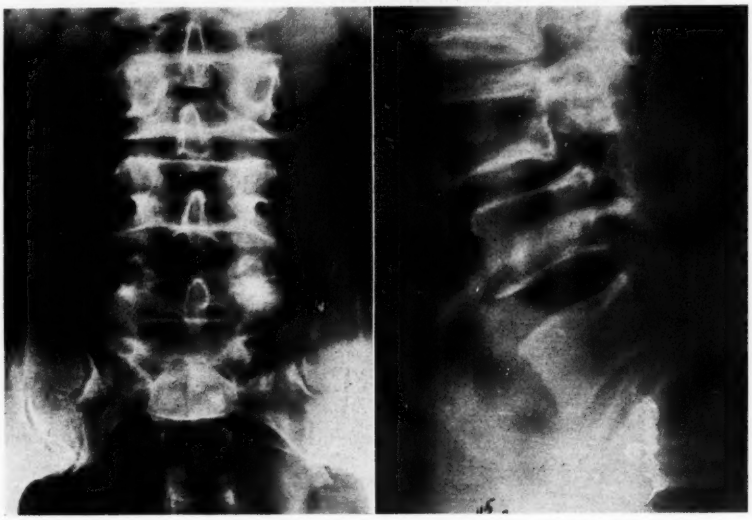

Fig. 7. Spondylolisthesis (graded 1) of the third on the fourth lumbar vertebra. *A (left),* anteroposterior view; *B (right),* lateral view.

spinous process of the sacrum. Anteroposterior roentgenograms disclosed a shortened lumbar spinous process, spina bifida occulta, and superimposed fifth lumbar vertebra on the sacrum. The lateral views disclosed spondylolisthesis (graded 2) of the fifth lumbar vertebra on the sacrum. The fifth lumbar body was narrowed posteriorly and the lumbosacral articulation was slightly narrow. The neural arch was distinctly separated.

Was the spondylolisthesis in this case present before the injury? Did injury disrupt the weakened support to the lumbosacral articulation and cause spondylolisthesis? Injury initiated the symptoms, and deformity had not been noticed. Callus could not be made out at the separation of the neural arch. It could be, and probably was, a congenital defect, strained by accident, and recognized only after symptoms appeared.

Case 2. A farm hand, aged 17 years, consulted the Clinic in 1928 because of flat-feet and pain in the knee. He did not complain of deformity or pain in the lumbosacral region, but a small prominence in this area led to the taking of roentgenograms. They disclosed spondylolisthesis of the fifth lumbar vertebra on the sacrum. The boy is carrying on his work. Should he meet with an accident, it will be of interest to note the effect it will have in producing pain and disability.

Case 3. A farmer, aged 36 years, complained of pain in the back and hips. Ten years previous to examination he had been crushed between a stone wall and a truck. His back was strapped and he used crutches for a time. Pain continued, and he sought relief for a chronic cough and stomach trouble.

Examination disclosed a depression over the fourth lumbar vertebra. Roentgenograms of the spinal column showed spon-

dylolisthesis of the fourth lumbar vertebra on the fifth. Duodenal ulcer and chronic bronchitis were also found. The patient refused operation.

This type of severe injury, involvement of the fourth lumbar veretbra, and sudden onset of pain, in a robust, hard-working farmer, would indicate the traumatic origin of the displacement.

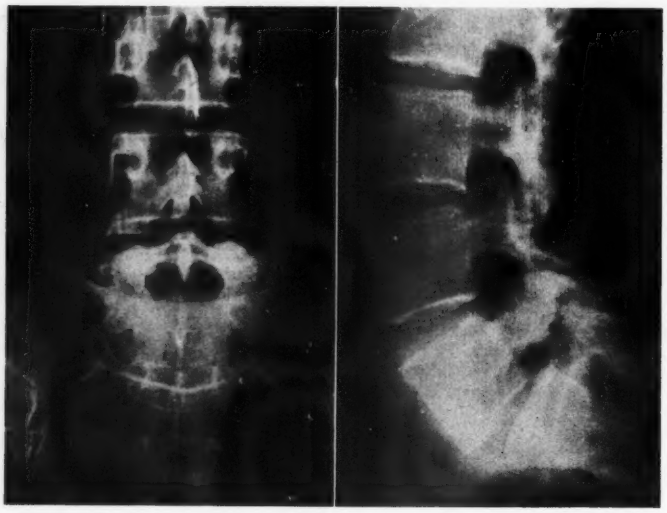

Fig. 8 (Case 4). Spondylolisthesis (graded 1) of fifth lumbar vertebra on sacrum. *A (left)* anteroposterior view; *B (right),* lateral view.

Case 4. A housewife, aged 38 years, complained of irritability of the bladder and weakness. She was nervous and consulted many physicians. She had been treated for constipation, hemorrhoids, cystic cervix, dental sepsis, eye trouble, and headache.

Roentgenograms of the kidneys, ureters, and bladder suggested the possibility of spondylolisthesis, but lateral views were interpreted as negative. The orthopedic consultant noted a rather acute angle of the fifth lumbar vertebra on the sacrum, but no definite slipping. The patient was questioned but she denied all symptoms of spondylolisthesis. She was urged to protect her spinal column by wearing a support.

She returned two months later. Symptoms referable to the bladder had disappeared, but now she complained of backache, pain in the sacro-iliac joints, and a "tight feeling" in the thighs and legs. She wore a corset, and complained of abdominal fullness, belching, and nervousness. There was no loss of weight and no weakness. Examinations of the urine, of the eyes, ears, nose, and throat were negative as was the Wassermann reaction of the blood. It was suspected that the spinal symptoms were partly due to nervousness (Figs. 8-*A* and 8-*B*). The roentgenologist made the diagnosis of spondylolisthesis of the fifth lumbar vertebra on the sacrum. The neurologist's report concerning the central nervous system was negative. The subjective symptoms were in the midthoracic and lumbar portions of the spinal column, and a depression above the sacrum was noted. The patient was treated for hemorrhoids and anal fissure and she returned home wearing a corset. Four months later she again returned, having gained 18 pounds in weight. She stated that

her health was good, and she felt well when wearing the support to the back.

Evidence obtained from available roentgenograms makes it probable that a mild degree of spondylolisthesis (graded 1) existed, as was first suspected, since, in the anteroposterior views of the lumbosacral region, the fifth lumbar vertebra was superimposed on the sacrum. The first lateral views were not found, but, after a two months' interval, deformity (graded 1) was obvious in the lateral views; the same degree of superimposition of the lumbosacral vertebra existed as at the first examination. The suggestion of symptoms by the physician to the introspective patient led to prompt assimilation and complaint, although the deformity had previously existed and pain had not been present. Again reassurance and support of the spinal column were enough to afford relief of the symptoms, after diagnosis had been verified. What the effect of an industrial injury to the back would have been can readily be surmised.

Fig. 9 (Case 5). Spondylolisthesis (graded 2), of fourth lumbar vertebra on fifth lumbar vertebra. *A (left)*, anteroposterior view; *B (right)*, lateral view.

Case 5. A housewife, aged 47 years, complained of leukorrhea, hot flashes, and constipation. A cyst of the uterus had been diagnosed. She had been treated for stomach trouble, and a chronically inflamed appendix had been removed and the abdomen explored. Roentgenograms of the stomach, kidneys, ureters, and bladder had been made 12 years before with negative results. On further questioning, the patient admitted having pain, which was aggravated by work, between the shoulder blades.

Examination of the spinal column disclosed a typical depression, with prominence of the fifth lumbar vertebra, muscle spasm, limited spinal motion, especially on forward bending, and tenderness on firm pressure and percussion of the lumbar portion of the spinal column and right costal arch. The patient did not remember any injury and had never received treatment for trouble of the spinal column. Trichomonas vaginalis were found. Roentgenograms of the thorax and stomach were negative. Lateral roentgenograms showed spondylolisthesis of the fourth lumbar vertebra on the fifth (Figs.

9-*A* and 9-*B*). Neurologic examination and the Wassermann reaction of the blood were negative. The patient was not concerned about the spondylolisthesis and did not wish to submit to any treatment, although she admitted having had backache all her life. In this case a severe injury would, no doubt, aggravate the condition and produce more definite symptoms.

Fig. 10 (Case 6). Spondylolisthesis (graded 3), fifth lumbar vertebra on the sacrum. *A (left)*, anteroposterior view; *B (right)*, lateral view.

Case 6. A youth, aged 17 years, had complained of aching pain in the left hip for two years. He thought he had always had a weak back, and working in the fields and stooping tired him more than it should have. Three years previous to admission he had fallen down twelve steps, and two years previously, while driving a cultivator, his left leg tired and ached, and he had to stop work and lie down at intervals in the field. In school the next year he had to lean forward and to the right, and stretch the left leg to relieve pain in the back. He consulted an orthopedist, and arthrodesis of the left sacro-iliac joint was performed without relief of symptoms. On further consultation eight months later, destruction of the fifth lumbar vertebra was discovered, and he was referred to the Mayo Clinic.

Examination disclosed typical signs of spondylolisthesis of the fifth lumbar vertebra on the sacrum (Figs. 10-*A* and 10-*B*). Roentgenograms disclosed spina bifida occulta and superimposed fifth lumbar vertebra on the sacrum. In lateral views, spondylolisthesis (graded 3), with separation of the neural arch, and narrowed fifth lumbar vertebra posteriorly were noted. Operation, with fusion of the lumbosacral region, benefited the condition.

Case 7. A machinist, aged 22 years, was struck across the lower part of the back by a falling tree five months before he came to the Clinic. The injury was followed immediately by paralysis of the sphincters of the rectum and bladder. An area of anesthesia around the anus following the accident. The sphincters slowly regained their power. The legs were not paralyzed. A body cast was applied and was worn for a week, and the patient was kept at rest in bed for two and a half months.

Examination showed a depression above

the upper border of the sacrum and limited mobility of the lumbar portion of the spinal column. A small area of anesthesia overlying the coccyx and moderate tenderness over the right border of the lumbar portion of the spinal column were noted. Roentgenograms showed spondylolisthesis of the lumbosacral joint and fractures of the transverse processes of the second, third, fourth, and fifth lumbar vertebræ on the right side.

Fig. 11 (Case 8). *A (left),* pre-operative anteroposterior view of spondylolisthesis graded 3. *B (right),* post-operative anteroposterior view showing author's method of using two bone grafts and multiple bone chips to fuse the third, fourth, and fifth lumbar vertebræ and the sacrum.

The patient was operated on March 16, 1929, and the third, fourth, and fifth lumbar vertebræ were fused in the sacrum. Improvement followed (Figs. 11-*A* and 11-*B*).

Case 8. A farm youth, aged 19 years, complained of pain in the back of two years' duration, which had been ascribed to rheumatism. Pain and swelling in the other joints indicated the presence of complicating arthritis, but general examination disclosed the short waist, the depression over the fifth lumbar vertebra, the spasm of muscles, and the limitation of motion. A clinical diagnosis of spondylolisthesis was made and verified by roentgenograms. The entire fifth lumbar vertebra was displaced forward so that the posterior quarter of the body rested on the anterior part of the sacrum. Spina bifida occulta was evident in the anteroposterior views.

A bone-grafting operation was performed and the symptoms in the back were relieved.

SUMMARY

Of the patients examined, 64 per cent were hard-working people. Their average age was 40 years and 71 per cent were men. The principal complaint was backache of almost nine years' duration. Although many patients had consulted physicians, and roentgenograms had been made, less than 10 per cent had been given a diagnosis.

Symptoms are relieved by rest; hard work, especially stooping and lifting, aggravate them. The patient may appear well and be gaining in weight. The anteroposterior roentgenogram may appear to be negative. Malingering may be suspected when the subluxation is slight and discernible only in lateral roentgenograms. Clinical

signs vary with the degree of deformity. A typical example discloses depression or lordosis of the lumbar spinous processes with prominence of the fifth lumbar spinous process and sacrum; in 86 per cent of the cases this region is involved. With increased subluxation, shortened torso and broadened pelvis occur; motion of the spinal column is principally limited on forward bending.

Although trauma is significant as an etiologic factor, it may be difficult to prove. The history and clinical data, when substantiated by evidence of fracture in the roentgenogram, are, however, conclusive. Roentgenograms taken previous to injury are seldom available. Symptomless spondylolisthesis occurred in 9 per cent of the cases.

A hard, bony mass is sometimes palpable low in the abdomen. Rectal examination, proctoscopic or manual, may disclose a narrowed anteroposterior diameter of the pelvis.

In about 2 per cent of the cases the spondylolisthesis was of the reverse type.

Congenital anomalies were present in a high percentage of cases.

Spondylolisthesis formerly, and at present, is seldom recognized in general practice. It is obviously associated with chronic backache. Roentgenologists may disclose its presence in spite of negative clinical data. We may look forward to an increasing incidence of this deformity in cases of chronic backache and injury to the spinal column as a result of the more common use of lateral roentgenograms of the lumbosacral area.

DISCUSSION

DR. MEYERDING (closing): Congenital anomalies accompanying spondylolisthesis are common. With better roentgenograms, I believe they will run between 70 and 100 per cent. Many of the older roentgenograms do not give differential evidence and it is impossible to judge the true conditions accurately. I have seen traumatic spondylolisthesis; I admit, however, that he who diagnoses traumatic spondylolisthesis must prove it. Many patients have this deformity with symptoms, but injury may aggravate a pre-existing condition causing pain, increased deformity, and even disability. If these cases are seen immediately, and good anteroposterior and lateral roentgenograms are available, they may show the presence of a fracture with spondylolisthesis. In such a case, there can be no question of what factor trauma has played.

PLASTIC SURGERY OF THE HIP[1]

By A. BRUCE GILL, M.D., PHILADELPHIA

PLASTIC substances can be molded easily, as they lend themselves to adaptation by external forces. But animate plastic tissues have an innate power of self-adaptation to changing conditions. Certain tissues of the body can be molded and reshaped by the surgeon's hand. They can be transplanted to other parts of the body, where they may serve a new purpose in the repair of bodily defects, but they also have an inherent capacity to adapt themselves to their new surroundings, to take on new functions, and, by growth, to meet greater demands placed upon them.

We have been accustomed to think that the soft tissues of the body are more plastic or changeable than the bones. Plastic surgery, for the most part, has meant the repair of defects of the face and skin grafting, to correct contractures and replace lost tissue. But we have learned that bones are also fit matter for the surgeon's plastic art, and, indeed, present even more remarkable and striking illustrations of that innate

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

Fig. 1, Case 1. Congenital dislocation, reduced bloodlessly but reduction could not be maintained. Patient was one and a half years of age.

Fig. 2, Case 1. Two and a half years after operation to reconstruct the upper portion of the acetabulum.

Fig. 3, Case 2. Congenital dislocation. Patient was twenty years of age.

plasticity which is a characteristic of living structures.

According to Wolff's law, the external form and the internal architecture of bone are determined by the mechanical forces which operate upon it, and are altered when the direction of stress and strain is altered. They adapt themselves to changed function and to altered mechanical forces. It is well known that the lamellæ of the head and neck of the femur are designed with exact mathematical precision in this peculiarly shaped bone to bear a given weight with the use of the least amount of material. This bone is as precisely adapted to the demands placed upon it as is a reinforced concrete building or a bridge. If the angle of the neck with the shaft becomes altered by accident or disease so that there arises a coxa vara, Nature proceeds to absorb all the lamellæ. Simultaneously they are replaced with new ones in different lines of direction which are as mechanically correct as were the old ones, and which bear the body weight with the same paucity of material but the same coefficient of safety. In cases of bony ankylosis of the hip, we frequently observe that Nature

Fig. 4, Case 2. Four years after reconstruction of acetabulum: normal motion: normal function.

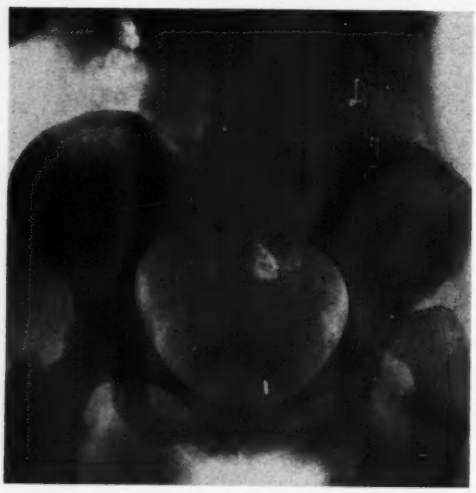

Fig. 5, Case 3. Congenital dislocation. Patient was seventeen years of age.

has laid down lamellæ which arise in the bones of the pelvis and sweep downward in curved, unbroken lines through the head and neck of the femur. The direction and curve of these lines may be entirely different from those of the normal femur, because the line of weight-bearing is different. A change of function has brought about a complete change of architecture. Here is an

Fig. 6, Case 3. Six months after reconstruction of the acetabulum.

exhibition of plastic power which soft tissues cannot surpass.

But there is another natural law, even more profound and mysterious than that enunciated by Julius Wolff. It is indeed amazing that Nature should construct her buildings in accordance with the laws of calculus and higher mathematics, that she should provide a maximum of efficiency with a minimum of materials, and, still more so, that she can tear down a structure and replace it with another without interruption of the continuity of its usefulness. But is it not more amazing to learn that growth and the very existence of a structure are dependent upon its serving a useful function in the body? The roots and ramifications of this law would lead us into the mysteries of all life and growth and into the secrets of evolution. But time and again we see it illustrated in the bony structures of the body.

If an emulsion of periosteum and bone be injected into the abdominal wall, it may form a plate of bone and show evidence of

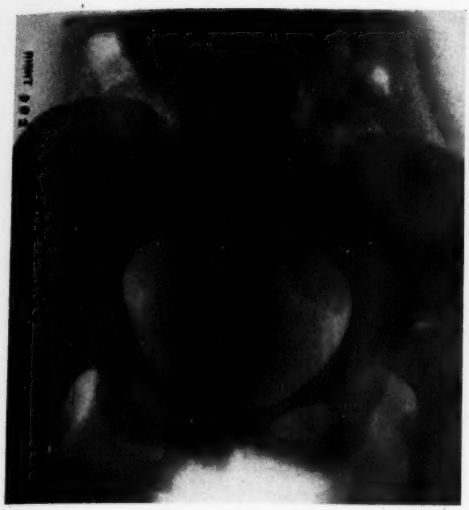

Fig. 7, Case 3. Two and a half years after reconstruction of the acetabulum.

Fig. 8, Case 4. Congenital dislocation of hip.

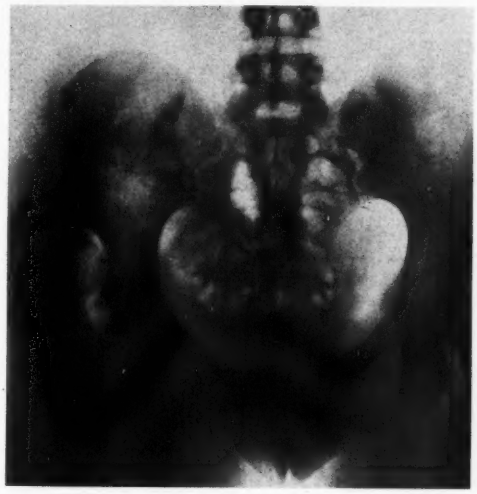

Fig. 9, Case 4. Two years after reconstruction of a new acetabulum on the side of the ilium. Almost normal motion.

some growth, but eventually it becomes completely absorbed, because it serves no function. If a portion of the fibula be transplanted to take the place of the upper end of the humerus, it will increase in size until it becomes of the same diameter as the humerus itself. A remarkable case was reported by Dr. Willard in which the lower end of a humerus was fractured. The lower fragment, together with the elbow and the forearm, was displaced backward. The posterior portion of the periosteum of the humerus was stripped from the lower half of the shaft and passed as a bridge from the lower fragment to the middle of the shaft. As time passed, this strip of periosteum grew and replaced the lower half of the humerus, the entire lower part of the upper fragment being absorbed. A large mass of bone lost its function and disappeared, while a small strip of periosteum, which preserved the continuity of bone between the shoulder and the elbow, grew to replace the bone whose usefulness was lost.

Therefore, we may see in the bones of the body beautiful illustrations of that inherent plasticity which is common to all living tissues and which makes not only their form and structure but their life and death dependent upon function. And we may expect plastic surgery of the bones to give particularly striking results.

Youth is more plastic than age, is more flexible, adapts itself more easily and effectively. Its reserve strength, its coefficient of safety, is greater. Repair is easier. In young bone, increased demand stimulates growth and strength; in aged bones, it may

Fig. 10, Case 5. Pathological dislocation of hip due to tuberculosis.

cause degeneration and a breaking down. In young individuals, we see a building up of bone if it is necessary and an absorption of unnecessary bone, a rounding and smoothing of a reconstructed joint such as the hip. In the aged, we observe the degenerative changes of osteo-arthritis following injury to the hip, or caused by the wear and tear of even normal function. There is fibrillation and splitting of the articular cartilage followed by its absorption, the formation of osteophytes from the subchondral bone, and a general roughening and irregularity of joint surfaces and margins.

These various characteristics of bone are well illustrated in certain conditions of the hip joint and in the reactions of the tissues following plastic operations.

Fig. 11, Case 5. Six years after reconstruction of the acetabulum with reduction.

Fig. 12, Case 6. Pathologic dislocation due to tuberculosis.

CONGENITAL AND PATHOLOGIC DISLOCATIONS

In congenital dislocations of the hip, we note the shallowness of the acetabulum, the lack of normal development of the epiphysis of the head of the femur, the misshapen head, the small size of the neck and shaft, and the version of the neck. All these conditions may be explained by the absence of normal function of the hip both before and after birth. As years pass the acetabulum

Fig. 13, Case 6. Four years after fusion of the femur with the pelvis. Note the marked growth of the femur and pelvis.

Fig. 14, Case 7. Old ununited fracture of the neck of the femur: necrosis of the head: complete absorption of the neck.

becomes more and more shallow and eventually may entirely disappear. It has become a useless structure and ceases to exist. Nature, in the meantime, is attempting to construct a new socket higher up on the pelvis, although in this effort she is never completely successful. If normal relationship of the acetabulum and the head of the femur be restored and function resumed, Nature returns to her labor of growth and of remolding of the structures.

The surgeon is able to inaugurate this work by replacing the head in the socket. If the latter is too small to contain the head, it may be deepened or reinforced by a bone shelf turned down from the side of the ilium. If, in old cases of dislocation, the head cannot be brought down to the site of the original acetabulum, a crude acetabulum may be constructed on the side of the pelvis above its normal situation. Nature then proceeds to strengthen this structure, to smooth it and round it neatly to fit the head. Figures 1-9 illustrate these processes in various stages. While we have found that a stable weight-bearing hip is always secured, the degree of mobility varies in different types of cases. When an entirely new acetabulum must be constructed high on the ilium, motion may be greatly limited, but it is frequently observed that, even in these

Fig. 15, Case 7. Whitman reconstruction operation.

Fig. 16, Case 8. Fracture of the neck of the femur.

Fig. 17, Case 8. Almost complete absorption of the neck in three months.

cases, the function improves indefinitely as Nature continues her modeling of the new joint.

Figure 1 shows the hip of a child one and a half years of age. Bloodless reduction had been secured, but it was found after six months' treatment in plaster casts that the femur would not remain in the socket. By an extra-capsular operation a bone flap was turned down from the ilium and the entire roof of the acetabulum was also forced downward. Both structures were held in their new position by bone wedges removed from the crest of the ilium. The final result two years later is shown in Figure 2. In such a reconstructed hip stability and motion are normal.

Figure 3 shows a subluxation in a patient twenty years of age. An operation similar to the preceding one was done. The result four years after operation is shown in Figure 4. Here, also, function is normal.

In Figures 5, 6 and 7 are illustrated the slightly higher luxations where a new acetabulum is made just above the original one. The capsule is opened. The upper rim of the acetabulum is gouged away until the head of the femur slips into the cavity. The structure is then made large enough with a bone flap to contain the entire femoral head. Motion is frequently moderately limited but is sufficient for normal activities.

Figures 8 and 9 show a new acetabulum constructed high in the ilium. In these, motion is still more limited, but at times, as in this case, it approaches the normal.

The development of these plastic operations has completely changed our methods of treatment of congenital dislocation of the hip. The author attempts a bloodless reduction in all cases under from four to six years of age. If it cannot be secured by gentle manipulation or if a reduction cannot

Fig. 18, Case 8. Arthrodesis of the hip.

be maintained after from four to six months in plaster, he then resorts to open operation. In former years nothing could be done for the cases that could not be reduced bloodlessly, or that would not remain reduced. Now we have a procedure for every condition, even in patients over twenty years of age. Bloodless reduction, even in children under four years of age, never gave a good result in more than 65 per cent of cases. Now we may expect the successful restoration of a normal hip in the remaining 35 per cent by open operation.

Pathologic dislocations present much the same problems as congenital ones. They are due to infectious processes which destroy the acetabulum or the head, or both, so that subluxations or complete luxations occur. In some cases, a new joint may be constructed which is both stable and movable; in others, an arthrodesis, or fusion of the femur with the pelvis, is the best solution of the problem. A single rigid painless hip is not a great handicap to the patient. He can engage in most of the normal activities of life; he can do everything but lace his own shoe. Figures 10, 11, and 12 show different types of these cases. Figure 13 illustrates beautifully the growth of the femur after weight-bearing function is resumed.

ANKYLOSIS OF THE HIP

At times it is desirable to restore motion in an ankylosed hip. This may be done by an arthroplasty, the indications for which, and the technic, have been so frequently described that they need not be repeated here. The author has had one occasion to open a joint a year after arthroplasty had been performed and he then observed how natural processes had smoothed and rounded the head of the femur and the acetabulum after function of motion had been re-established.

FRACTURES OF THE NECK OF THE FEMUR

Ununited fractures of the neck of the femur fall within the field of plastic bone surgery. In a certain percentage of them, union may be secured by a bone graft, but grafting is useless unless union of the two fragments occurs. It has been observed that, for a time, a bone graft alone is able to bear the weight of the patient, but that eventually it is absorbed, and, unless union of the fragments has taken place, the condition of the patient is the same as before operation. By what means may it be known whether or not union may be expected to follow operation? The unfavorable cases are those in which complete, or almost complete, absorption of the neck has taken place and those in which the absorption was apparent soon after the fracture and progressed rapidly. It is essential, when the X-ray examination is made, that the femur should not be in a position of either internal or external rotation. Complete death of the femoral head,

which is indicated by its comparative greater density on the X-ray film, may be considered as a contra-indication to a bone graft operation.

If the surgeon decides against such an operation to secure union, he is then limited to a reconstruction operation. In this procedure he removes the head of the femur, cuts off the greater trochanter and moves it down on the shaft, and places the upper end of the femur in the acetabulum. Unfortunately, there is a tendency for the femur to slip from the socket and for osteo-arthritic changes to occur, particularly in older patients. As a result of this, the patient may have a painful and unstable hip. The author's experience with the Whitman reconstruction operation has not been encouraging. Therefore, in recent years, he began to attempt an arthrodesis of the hip after all other operations had failed. Later he has employed this operation in preference to the reconstruction operation, and in two cases he induced arthrodesis in the hip three months after the fracture when there had been meanwhile complete absorption of the neck. These various procedures are illustrated in Figures 14, 15, 16, 17, and 18.

The roentgenologist will assist the surgeon in his solution of the problem of the treatment of fractures of the neck of the femur by noting degenerative osteo-arthritic changes in the hip joint present at the time of the fracture, by observing how rapidly the neck undergoes absorption, and by learning to diagnose death of the femoral head. In not more than from 50 to 60 per cent of these fractures can we expect union to occur by the best conservative treatment, and in not more than probably from 70 to 75 per cent by open operation. We must learn to distinguish early those cases which seem to be doomed to non-union from the moment of fracture in order to preserve them from many months and even years of useless treatment, pain and disability. Possibly an arthrodesis of the hip soon after the fracture is the best solution of these cases, but this entire field is still open to study, observation, and research. The roentgenologist and the surgeon must work hand in hand to solve this very important, but very difficult, problem.

The author trusts that this very brief discussion of the possibilities of plastic surgery of the hip may be of interest to the roentgenologist, as well as to the orthopedic surgeon, as both so frequently see the tremendous reconstructive powers of Nature working according to law, both learn to read on the X-ray film the story of what has been taking place within the hip joint, and both must increase their powers of observation in order to solve important problems.

THE ADVANTAGES AND DISADVANTAGES OF SMALL CHAMBER MEASURING INSTRUMENTS[1]

ANALYSIS OF BACK-SCATTERED RADIATION

By HOWARD B. HUNT, M.D., Department of Radiology, University of Nebraska, OMAHA

IN the determination and analysis of actual dosage delivered at the surface and within the body, the clinical and laboratory advantages of access and localization, offered by a small chamber measuring instrument, have been utilized for some time by various observers (1, 2, 3). The disadvantages of the small chamber iontoquantimeter have rested in the physical imperfections of the instrument, namely, lack of sensitivity, frequency of leakage, alterations in capacity, and dependence on wave

[1]Read at the Annual Meeting of the Radiological Society of North America, at St. Louis, Nov. 30–Dec. 4, 1931.

length. These defects have resulted from the relatively small transfer of electricity, the difficulty of maintaining an extensive insulation, necessary along the connecting cable or rod, the insecurity of construction, and absorption by, and secondary radiation from, the walls of the chamber. Fortunately, the physical dependability of these instruments has been greatly improved during the past few years through the studies of Failla (5), Taylor (6), Glasser (4), and others, together with the support of the manufacturers.

An iontoquantimeter consists of an ionization chamber and an electrometer for the measurement of the electrical transfer resulting from the ionization produced by the traversing radiation. All regions of the instrument, except the ionization chamber, must be shielded against radiation. The small chamber usually consists of a grounded spheroid, or thimble-shaped wall, and a centrally placed charged rod, connected with an electrometer system and well insulated from the frame. The rod can be charged to a saturation potential (4, 12) sufficient to transport all ions by means of a static charger, although a small transformer, or an induction coil, is occasionally used for a source of potential. The rate of loss of a static charge across the chamber can be measured by a simple leaf electroscope, or a string electrometer. The intensity of the current flowing from a more sustained source across the chamber can be measured by a sensitive galvanometer, a micro-ammeter, or a potentiometer with a vacuum tube amplifier (7). The most generally dependable electrical system in the portable small chamber instrument appears to be a reliable, built-in, static charger and a simple string electrometer.

A means must be available whereby the constancy of the calibration can be periodically checked. The constancy of the response of the instrument to radiation can be checked by a radium standard (9, 10). Given a particular 5 mg. needle, replaced in the same definite relations to the chamber, the ionization will be identical and the electrometer reading may be reproduced, unless the electrical capacity or conductivity of the system has been altered. In case the scale deflection is not reproduced, it will be necessary to correct the readings accordingly, or to have the instrument recalibrated. The Victoreen instrument is provided with a capacity check, whereby an added fixed and definite capacity is added to the system, thereby dissipating the total charge by a constant reproducible deflection. The added condenser may also be made use of in converting an instrument designed as an intensimeter into a dosimeter by means of the increased capacity. All small chamber instruments must be calibrated and checked against a standard chamber (8), preferably against a large air chamber.

In a small chamber instrument, the extensive insulation which must be maintained increases the frequency of leakage. This may introduce a very significant error in small chamber determination, since the total ionization current is relatively low. Leakage appears most troublesome in those instruments provided with long flexible cables. When the leakage is due to a thin film of moisture overlying the insulation, it will frequently cease after the instrument has been in a drier atmosphere for a few hours. A persistent leakage must be deducted from the total electrometer reading. The lower the intensity of radiation measured, the more significant the leakage becomes. The Victoreen "r-meter," which we are now using, shows a negligible leakage of 0.01 r/minute. In case leakage becomes variable or in excess of 10 per cent of the usual determination, the instrument should be overhauled by the maker or a similarly qualified expert.

The ideal chamber possesses a wall having an effective atomic number equal to that

of air (4, 5), in order that the coefficient of absorption and of scattering may be unaltered from that of air. Furthermore, the density should be equal to that of air in order that the integrated absorption and

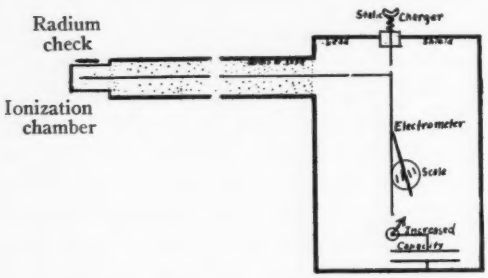

Fig. 1. Small chamber iontoquantimeter.

scattering may be unaltered by the wall. This is feasible only in a true air wall chamber (6) bounded with guard rings and housed in the depths of a bulky system. However, if this is used, the practical advantages of accurate localization and ready access are lost from the small chamber instrument. Glasser (4) and Failla (5, 7) have devised small chamber walls which are relatively independent of wave length over those ranges which are routinely used in roentgen therapy. The approximate correction factors for a Victoreen "r-meter" have been prepared from data supplied by Darnell in a personal communication. The readings are only about 2 or 3 per cent low at 90 K.V.P., through no filter, due to a slight absorption by the wall; they are only about 2 or 3 per cent high at 200 K.V.P., through 1 mm. of copper, due to increased secondary radiation from the walls, rod, and stem. This covers the usual therapy range with a satisfactory degree of accuracy. However, filtration through 2 mm. of copper appears to introduce an appreciable discrepancy, the reading being about 18 per cent higher than with an air wall chamber. Again it is seen that the small chamber instrument is a satisfactory working tool even though it is not always an instrument with physical precision.[2]

As shown in the accompanying graph, the excursion of the electrometer indicator for a unit of radiation may differ in the various sections of the scale. The scale may readily be calibrated by constant radiation, such as that from a radium needle or from a stable X-ray circuit. It is seen that an error equal to 6 or 8 per cent may be introduced through reading across only the last five scale divisions. This is usually avoided by beginning the reading at zero. In case the indicator is carried through only the left five spaces of the scale, the uncorrected reading with this instrument may be 3 or 4 per cent below the reading for the entire scale. The probability of error may be lessened by carrying the indicator across at least two-thirds or three-fourths of the scale. The error in reading the scale alone becomes greater than 1 per cent when less than 10 divisions of the scale concerned are traversed.

The calibrations of all ionization chambers are altered by variations in the density of air as altered by changes in temperature and barometric pressure. Alterations of this type, if no correction be made, may readily introduce an error of 5, or even 10, per cent on a warmer summer day in Omaha, according to the tables supplied with the Victoreen "r/meter" from which this graph was compiled. Both large and small chambers are subject to this source of error.

Portability and adaptability of placement are desirable features in a general laboratory dosimeter. The self-contained small chamber instrument can be made to provide both features more satisfactorily than can the large chamber. We have provided adaptable placement and firm support for our "r/meter" by mounting it on an idle

[2]A more recent Victoreen intensimeter of modified design is said to be accurate within 6 per cent for both extremes of wave length, from 30 K.V.P. radiation down through the gamma range (200 K.V.P., 2 mm. Cu gives 0.14 A. by Richtmyer formula, see Fig. 2).

tube stand. This facilitates the manipulation of the instrument for use as an intensimeter, dosimeter, penetrometer, and general laboratory instrument. However, the meter may be readily removed from the stand and used elsewhere in the department, or carried outside for use in the calibration of other X-ray generators.

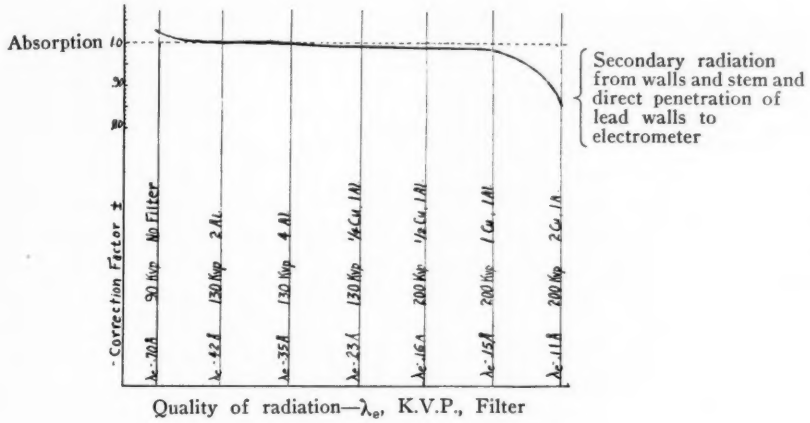

Fig. 2. Calibration of a small chamber iontoquantimeter according to quality. Applicable only to this particular instrument.

Through the use of the mounted small chamber iontoquantimeter, it has been possible to record and to analyze observations relating to actual dosage, which would not have been possible with a large chamber instrument. No new findings have been disclosed, but a few fundamental principles (1, 2, 3) have been re-emphasized. The instrument may be readily adapted as a penetrometer through immersion of the chamber within a rice or water phantom, or insertion of it within the body cavities. Placement of the chamber, covered with a thin rubber tube, within the upper vagina will thus provide an index of the radiation delivered to the cervix or ovaries.

By means of the small chamber, radiation delivered at the surface of the body can be analyzed in terms of the primary and back-scattered components. This is of educational value, since an appreciation of the practical factors controlling the intensity of both primary and secondary radiation is an essential in the principles of radiation therapy. Back-scattering may increase the total skin dosage by as much as 65 per cent of the primary radiation, or by as little as 5 per cent, depending on the size and contour of the field, consistency of the region irradiated, and the effective wave length of the incident radiation. In the incident radiation alone analysis shows an increase amounting to 12 per cent, in going from a field 3 cm. to a field 20 cm. in diameter. The increase in the intensity of the back-scattered radiation may equal from 15 to 50 per cent of the corresponding primary radiation. The total skin dosage may, therefore, be increased anywhere from 25 to 60 per cent on increasing the diameter of the field from 3 to 20 cm., depending on the consistency of the region and the individual patient. Further enlargement of the field appears to add only a slight increment to the intensity of the back-scattering.

An analysis of back-scattering from various body areas and various patients shows that the denser and more bulky regions emit the greatest intensity of secondary radiations. The less dense regions, such as the

chest and gas-distended bowel, and less bulky structures—the extremities, for instance—emit proportionately less secondary radiation. For example, the buttocks may return back-scattered radiation having an intensity equal to 40 or 60 per cent of the primary, as compared with 30 or 40 per cent from the chest, and 20 or 30 per cent from the extremities, even though there be no variation in field size. Different patients give variations in intensity of back-scattering from the same region, which may alter the total dosage by 15 or 20 per cent.

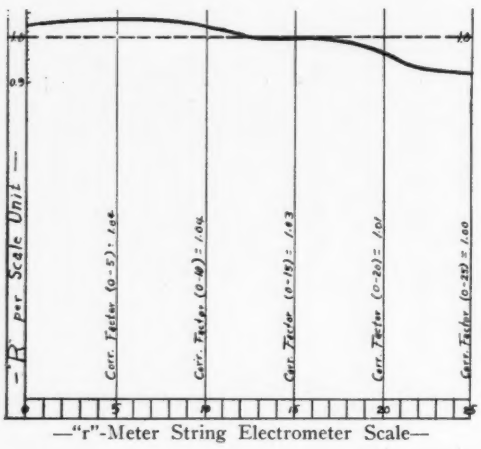

Fig. 3. Calibration of an electrometer scale by γ-radiation.

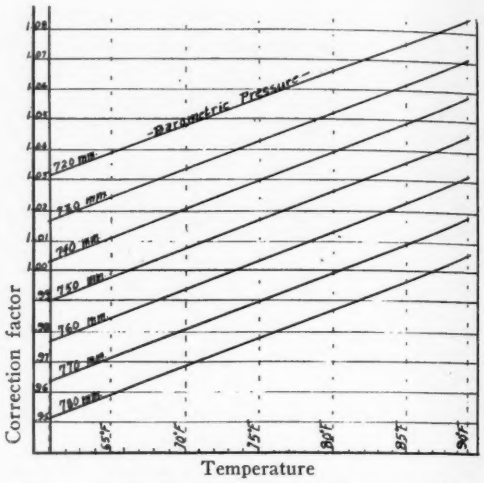

Fig. 4. Calibration of iontoquantimeter according to barometric pressure and temperature (adapted from Victoreen No. 218 chart).

Significant determinations regarding back-scattering can also be made from paraffin phantoms. A graph presents measurements of effective back-scattering excited by primary beams of various effective wave lengths. The wave lengths were estimated from the slope of their logarithmic absorption curves by means of Richtmyer's formula (11):

$$\mu_\lambda/\rho = A\,\lambda^3 + K$$

The wave lengths for the no-filter determinations are necessarily only roughly approximated. On changing from unfiltered to filtered radiation, it is seen that the intensity of back-scattering is increased from 20 to 40 per cent of the primary intensity. It is increased from an intensity equal to 40 per cent of the primary to an intensity equal to 50 per cent of the primary radiation on changing from filtration through 1 mm. of aluminum to filtration through 1.4 mm. of copper. It is probable that the decrease in surface back-scattering observed with a longer primary wave length results chiefly from the elimination of an increasingly large portion of it within the scattering medium. The denser the scattering medium, the more obvious becomes the effect of wave length on the intensity of surface back-scattering (12). Observations regarding the relative wave lengths of primary and secondary radiation may explain the manner in which a variable portion of the secondary radiation can be trapped within the scattering medium.[3]

It was possible to estimate the comparative effective wave lengths of primary radiations and the back-scattered radiation excited by it from a paraffin phantom. A 4

[3]Paradoxically, back-scattering is definitely diminished with wave lengths shorter than 0.23 Ångström (see plot points in Fig. 7), and becomes reduced to 30 or 35 per cent at 200 K.V.P., 2 mm. Cu.

mm. lead hood, open only at the bottom where it was in relation to the back-scattering medium, was placed over the chamber, shielding it against the primary beam. Graded filters of copper and aluminum were inserted in the port opening into the chamber from the back-scattering medium, the effective wave length being calculated by means of the Richtmyer formula (11), from the slope of the absorption curves for both the primary and back-scattered radiation. The measurements relating to the primary radiation were made by reversing the hood, thus directing its port toward the X-ray tube.

The results appeared to be roughly in accord with the refined measurements of Compton (12) by means of the spectrograph (13). A primary effective wave length of 0.15 Ångström was scattered to 0.24; a primary wave length of 0.23 was lengthened to 0.31, and a primary wave length of 0.43 was increased to about 0.50. According to Compton, a single scattering through 180 degrees increases all wave lengths by about 0.05 Ångström. Referring this finding to our determinations, it would appear that many of the back-scattered rays had been scattered twice before reaching the surface. It is significant that scattering tends to produce a relatively much more dampening effect on the very short wave lengths than on the longer wave lengths. This may be somewhat compensated for by more multiple scattering from the shorter primary waves. The experimental errors involved in these observations do not warrant such a discriminating statement, although it is a plausible supposition. Many of the rays scattered from the longer wave lengths are probably so soft as to be absorbed before reaching the surface. Referring this generalization to our previous statements regarding back-scattering, it is obvious that at all times we referred to effective surface scattering, that is, total scattering minus that portion which was absorbed before reaching the surface.

SUMMARY

1. The small chamber measuring instrument is not an instrument of extreme physical precision.

2. All small chamber instruments should be calibrated by means of a standard air chamber and checked at intervals against a standard source of radiation or a standard chamber.

3. Readings must be corrected for variations in temperature and barometric pressure. They must also be corrected for wave length dependence, electrometer scale variations, and leakage, when these factors become of significant magnitude.

4. The physical disadvantages of the small chamber, such as dependence of wave length, leakage, and relative insensitivity, appear to have been sufficiently minimized in the modern high-grade instrument to allow its use in the usual range of X-ray dosimetry, the error being less than 3 per cent. Significant errors may be introduced when measuring wave lengths shorter than 0.14 or longer than 0.80 Ångström even with a good commercial instrument.

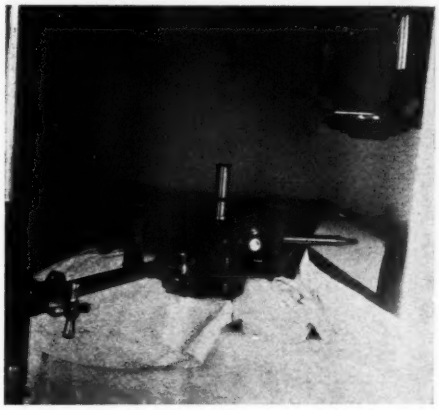

Fig. 5.

5. Distortion of readings for short wave lengths makes it difficult to estimate accurately effective wave lengths shorter than 0.14 Ångström by means of our small chamber.

9. In view of these many variables, it appears fallacious to calibrate r output with one size cone and one back-scattering medium, and to apply this one dosage value indiscriminately to all regions with all sizes of fields. It is more honest to measure routinely the dosage in air and estimate the total biologic dosage, or to make direct intensity delivery measurements at the point in question with the small chamber iontoquantimeter.

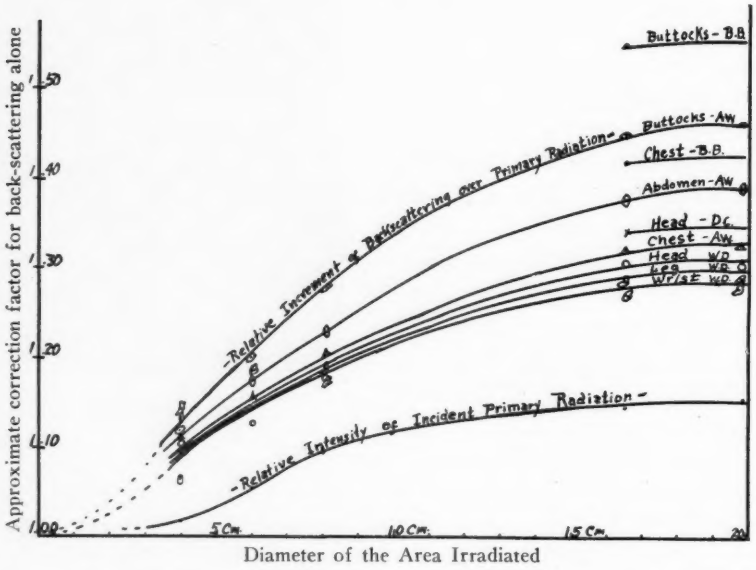

Fig. 6. Relation between intensity of back-scattering and the size and consistency of the area irradiated. $\lambda e = 0.23$ Å., distance = 42 centimeters.

6. The small chamber offers the advantage of accurate local placement, enabling one to measure skin dosage and estimate depth intensities.

7. It is a desirable teaching instrument, providing a means of analyzing the factors controlling intensity and quality of secondary, as well as primary, radiation.

8. Analysis shows that back-scattered radiation may increase the total skin dosage by from 5 to 65 per cent, depending on the size and contour of the field, region of the body, consistency of the patient, and the effective wave length. The relation of these factors to the intensity of back-scattering is presented in graphs.

10. Alterations in estimated dosage by from 10 to 50 per cent, due to variations in scattering, submerge an error of 2 or 3 per cent, which may be involved in the measurement of that dosage by the small chamber instrument.

11. The relative effective wave lengths of primary and secondary radiation were estimated by means of absorption curves made with the small chamber iontoquan-

timeter. The secondary rays were lengthened by from 0.07 to 0.09 Ångström, suggesting multiple scattering of many rays.

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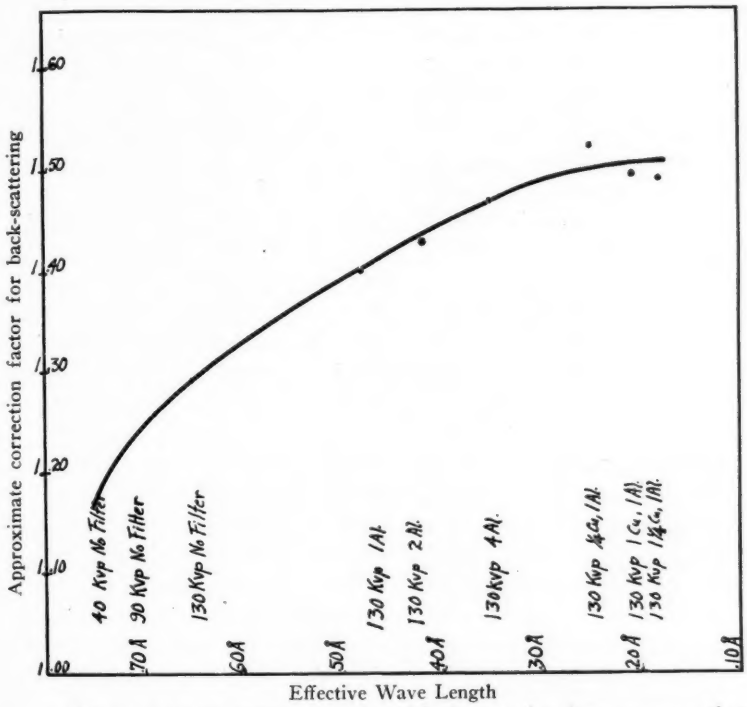

Fig. 7. Relation between intensity of back-scattering from parowax phantom and quality of incident primary radiation. Field = 20 square centimeters.

PREVENTION AND TREATMENT IN CERVICAL UTERINE CANCER[1]

By FRANKLIN I. SHROYER, M.D., DAYTON, OHIO

TO-DAY, the most important factor in our fight against cancer is being overlooked by some. There is a clear principle that runs through all the various etiologic factors, namely, that thermal, chemical, and mechanical irritations play a part in cancerous development, and chronic and subacute infections are preventable in all. The question is at once asked, "Why, then, are there not more cancers, since almost every person has had some part of the body exposed to irritation, and since infection of various forms is present in almost every person's body?"

This question is readily answered. Fortunately, the greater number of persons have a body resistance which is too great to allow cancer cells to develop, while there is no doubt but that a certain number of us have a natural immunity. The fact that not all infections lead to cancer is puzzling to some students, but it need not be so, because certain persons have the resistive powers within their cells to conquer the infection and destroy it.

Immediate operation should never be performed upon any malignant condition. The unfortunate individuals should be put upon a detoxicating diet, with colonic irrigations of two quarts of hot sodium bicarbonate solution morning and evening, until there is a noticeable softening of the mass and a reduction of the surrounding inflammation. About two weeks of such treatment will give the desired result. During the detoxicating régime, the surrounding lymphatics should be thoroughly irradiated. The radium should be sufficiently screened to prevent an erythema.

The mistaken idea that the etiology of cancer must date back to some specific thing has been a great drawback to the proper understanding of the subject. There are no facts known to medical science which justify this idea. Evidence pointing to the contrary furnishes us with a basis upon which we are able to formulate methods of prevention and cure.

The most important factor in the proliferation of cells cannot be other than the presence of low-grade micro-organisms of pathogenic origin. Most of the chronic pains and aches which afflict the human body are caused by a localization of infection. These same micro-organisms, by their incessant production of poisons within the body, are the cause of old age. Carcinoma, sarcoma developing in the uterus, hypernephroma developing in the upper pole of the kidney, carcinoma developing in the breast, gliomas in the brain—all have etiologic factors peculiar to the organ in which they are located. It is, therefore, logical to believe that the irritating factors which cause the one certainly are similar to those causing the other. Cancer, or cell proliferation, develops in an area of lowered resistance at a point at which insult to the tissues has occurred. Thus the germ finds a more favorable culture medium and there is consequent irritation.

Malignant tumors of any organ are divided into connective and epithelial tissue cell types. Of the epithelia, there are two varieties, carcinoma and epithelioma. Carcinoma may develop in the mucous membrane between the uterine cervix and fundus, in the surface epithelium, or in the glands of the cervix. The two types of connective tissue malignancy are sarcoma and epithelioma. In the latter, epithelial cells of the lymph channels and blood vessels become in-

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

volved. In the former, sarcoma develops in the tissue of the endometrium.

Carcinoma of the uterus has three distinct fields of development:

1. The absolute end of the cervix in an old infected scar or tear. This can easily be seen vaginally. 2. The cervix proper, extending from the external os up through the vagina to the internal os. 3. The uterine walls, beginning in the mucosa or endometrium, from the internal os to the fundus of the uterus.

Histologically there are two kinds: cylindric-cell, or adenocarcinoma, and squamous-cell carcinoma. Cylindric-cell carcinoma of the endocervix originates in the cell covering the endocervix or in the cells of the cervical glands. Carcinoma of the body, which is nearly always of the cylindric-cell form, originates, as does that of the cervical canal, either in the surface or in the glandular epithelium. Of the different anatomic varieties, carcinoma of the cervix is by far the most frequent. This structure is involved in approximately 90 per cent of all cases. Squamous-cell cancer of the cervix nearly always develops in the epithelial covering of the vaginal portion. Its origin is more probably the result of metaplasia of the surface epithelium.

In cancer of the cervix, the growth appears as a small, hard, indurated nodule in the wall of either the anterior or posterior lip—a more or less diffuse or papillary growth. There are really few malignancies that have their origin in the uterine body proper. Sarcoma of the uterine body does occur, but it is rare. Carcinoma of the cervix is easily accessible and is readily seen and recognized. Inspect the cervix for precancerous lesions. A nodule circumscribed and indurated on the cervix, a deep ulceration which bleeds easily, should always be viewed with suspicion. A cauliflower growth on the cervix is readily recognized as a cancerous growth. A cervix that has long been assaulted by bacterial invasion from the intestinal tract will certainly undergo degeneration frequently, whether the patient has been pregnant or not. Every cervix is a field for cancerous degeneration. When the lymphatics are disabled by foreign poisons, they are easy victims for the cancer cell, and it is through these channels that the malignant cell travels. Pain in cervical cancer is the last of numerous signs of the destructive process going on. Digital examination of the endocervix is not enough: the cervix should be palpated between the index finger and thumb throughout its entire length. Tears frequently take place along the cervical canal with no visible lesion of the endocervix, these tears constituting sites of scar tissue with infection, small cysts, and cervical myomas. To look at a cervix and say there is no tear is inexcusable. These infections within the canal will produce an endometritis, with complete fibrous degeneration of the uterus. All unrepaired tears heal with infection and leave scar tissue. After expert surgical repair, none of these conditions will be found.

The common cancers, such as epithelioma, medullary cancer of the cervix, and scirrhous cancer of the breast, do not start as cancer. Their very beginning dates back to some small pathologic lesion, possibly a mastitis, a tight cyst in the breast, a submucous myoma, a severe, or even a slight, laceration of the cervix. The effect of bacterial toxins upon lesions is the causative factor; therefore, in order to prevent cancer, we must begin at the beginning of the contributing cause.

Adenocarcinoma of the uterus arises in the mucous membrane of the uterine cavity. It is a rare condition in young women, but is rather common in women advanced in years and those who have not borne children. It is most readily cured by dilating the cervix and applying 50 mg. radium for 24 hours to the uterine cavity. In uterine cancer, glandular involvement occurs much later than in any other portion of the body.

A complete physical examination is always essential, as the following case will illustrate.

Mrs. K. consulted me six years ago because she was always tired, irritable, nervous, bloated after meals, and constipated. I examined her thoroughly and found that there was a bilateral tear of the cervix, a boggy uterus, and a leukorrheal discharge. I advised her to have a cervical repair and rid the uterus of infection, as this ought to cure her completely. She did not have this done at the time. Four years later, an osteopath sent this same patient to me again. By this time she was sorry she had not taken the advice in the first place. During the interval she had consulted three or four doctors and each one told her I was wrong—that she was having no trouble from the tear—that it was healed. I wish to state again that "the old scar in a healed cervix is just as dangerous as a new infected tear, because it was infected before it was healed." She had been treated for indigestion, tired heart, and had received four weeks' treatment in a hospital for nervous breakdown. Several weeks after hospitalization, she had moved to the country and was treated for rheumatism for a period of one year. At last she sought osteopathic treatments. Shortly after this, following a severe hemorrhage, she was referred again to me. A large cauliflower growth had completely involved the cervix. The cervical tear and scar could no longer be seen.

The woman died four months later with medullary carcinoma, at the age of 42 years, all because of inefficient diagnosis and neglect of early treatment. There is no excuse for such an error in diagnosis. "We are all too afraid of offending one another." This patient was treated for all the symptoms and not once for the underlying cause. You will agree that, if we make a mistake and are told about it, it will not happen again.

Every woman should be examined by a competent gynecologist, because he will be able to recognize a cervical lesion and to institute proper treatment for childbirth injuries, if such exist. Obstetricians are learning to direct their patients to return for further examinations, but these should be made at the end of six months, or one year, instead of three or four weeks after childbirth. Any cervix presenting a wide open mouth is diseased; any cervix that is cystic and swollen is diseased. All uteri larger than normal are infected and subinvoluted, and all subinvolutions are due to infection at childbirth or abortion. Cervical infections with subinvolution of the uterus will make nervous wrecks out of their hosts. Every infected cervix and uterus treated and cured is a precancerous lesion eradicated.

Cancer patients should all be grouped together and intensively studied. There has been, and still is, a tendency to overemphasize operations. A few days will not make much difference in the prognosis of a cancer. Once well developed, it is the most difficult disease to cure, but it can be cured, if it is seen in its beginning. The physician must not be careless or indifferent in making an examination, and the examination is not complete unless every organ has been checked. The physician must be able to correlate the different pictures presented by disease and he must also be able to visualize disease.

Quigley[2] says: "One reason why medical men have made so little progress with cancer is that they have paid so little attention to the conditions that lead up to the development of cancer. The men who deny or reject the term 'precancerous' are those trained on only one side of the cancer question. They are either laboratory men without clinical experience or medical men without laboratory experience and with little knowledge of fundamental medical science. I have never known a medical man of wide experience and proper knowledge of funda-

[2]Quigley, D. T.: The Conquest of Cancer by Radium and Other Methods. F. A. Davis Company, Philadelphia, 1929.

mental medical science who denied the precancerous stage in dealing with the disease."

To remove a part of the uterus and leave the cervix is inviting disaster to the patient in later life. If the body of the uterus is diseased enough to necessitate removal, then the cervix also is, excepting in the case of a uterus that has never been impregnated and not myomatous. Adenocarcinoma of the uterus is rarer than cervical cancer; it grows more slowly and has a tendency to remain restricted to the uterine body. This form of cancer occurs in later life, restricting itself because of the beginning atrophy of the uterus and pelvic lymphatics in women about the age of fifty years. "The Journal of Cancer Research" recently stated that the incidence of the development of cancer on the cervical stump after subtotal hysterectomy is more than 4 per cent. Dr. Robert Monad, of Paris, states that cancer of the cervical stump began to be noticed more frequently when total hysterectomy was replaced by subtotal hysterectomy. The apparent rarity of this condition may be estimated from the fact that, up until 1921, only 80 cases had been reported in the French literature. Between 1920 and 1931, 180 cases of carcinomas of the cervical stump were treated by radium in six different cancer centers in Paris, and, during this period, 300 cases were recorded in the French literature. The incidence of carcinoma affecting the cervical stump after subtotal hysterectomy is reported as varying between 5 and 6 per cent. This is distinctly higher than the incidence of carcinoma of the cervix. From the Curie Institute, it is reported that five out of six cases of carcinoma of the cervical stump, appearing within one year after the operation, were glandular in type. These observations suggest that the glandular carcinomas appearing so soon after operation are actually recurrences of the previously indicated malignant lesions of the uterine mucosa. The co-existence of myoma and carcinoma is far from exceptional. Every surgeon should keep this in mind when operating for uterine myoma. Monad agrees with Faure that, for myoma of the uterus in women during the menopause, total hysterectomy is the method of choice. Monad and Moreston, of Paris, both agree that the only way to perfect subtotal hysterectomy is to perform a total hysterectomy: the various modifications of subtotal hysterectomy are not satisfactory. If total hysterectomy is not advisable, then 50 mg. radium are applied to the uterine cavity and the cervix, screened with 2 mm. brass and 1 mm. hard rubber, for 24 hours.

The prognosis in carcinoma of the cervical stump is more grave than it is in carcinoma of the cervix in which the uterus has not been removed. Surgical treatment, according to the Curie Institute, Paris, has failed, and radium is the method of choice. The opinion of all leading authorities, as compiled by the Department of Cancer Research at Columbia University, is that the sure prophylactic measure against carcinoma of the cervical stump is to increase the practice of total hysterectomy. The number of operative deaths from the more radical procedure will be less than that from carcinoma of the cervix. From a therapeutic standpoint, the treatment of choice is radiotherapy; therefore, it is being taught, and it is the opinion of men of broad experience, that cancer is preventable and curable. To remove a part of the uterus and leave a cervix is distinctly poor judgment; even to enucleate a cervix in the procedure of total hysterectomy is cheating the patient. The mortality rate from total hysterectomy is no greater than that from subtotal hysterectomy, if blood loss is controlled. Ligatures should take the place of too many hemostats, since the latter cause bruising. It is not necessary to use more than 10 or 12, at the very most.

In the breast, an adenoma is not cancerous, but it is surely precancerous. Ade-

noma grows slowly within its capsule or sac. One reason for the peculiar susceptibility of the female breast tissue to cancer is the fact that, from puberty to old age, the epithelium is never at rest. Hypertrophy takes place at every menstrual period. Between periods, the epithelium is either growing, as the period appears, or shrinking, following menstruation. Every month the epithelial cells are stimulated by hormone growth. Infection is the most prominent precancerous condition in the lactating breast, and injury is the most prominent in the non-lactating breast. These two etiologic factors work together in either case, both trauma and infection being present. Infection and injury will produce scars and interfere with drainage, so that stagnation occurs. Stagnation in any part of the body leads to loss of vitality, causes illness, and, finally, death to the part affected. Food must be carried to each and every cell. The incoming food material is carried to the arteries, and the outgoing waste material is carried away by the veins and lymphatics. The microscopic finding of basement membrane broken through by epithelial cells does not mean just cancer—it means advanced cancer. The average pathologist is trained to recognize cancer only after basement membrane has been broken through. He, therefore, labels many cases benign, which in reality are malignant. He misses all the early stages of the disease. A lump in the breast of an old or middle-aged woman should always be considered cancer until it can be proved otherwise. The woman who, at the age of 25, carries a more or less benign adenoma in her breast, carries, if she does not have it removed before the age of 35, a cancer. General practitioners and surgeons must, therefore, correlate symptoms, thereby visualizing the outcome of an apparently harmless condition. When this method is followed, the death rate from cancer will surely decrease.

In removing a breast, I make a wide excision, remove supra- and infraclavicular and axillary glands, then transplant a flap from the other breast over the area of removed breast. Results are excellent and no skin grafting is necessary. The treatment of cancer of the breast would be effective if early irradiation were instituted. Postoperative radiation has, no doubt, added from 8 to 12 per cent to the five-year cure of all cases operated upon. Radiation therapy should always be administered by one who is competent to do so in a scientific manner, with proper equipment. I have always advocated pre-operative radiation in any suspicious growth. I have also been a profound believer in repeated doses over short periods of time. I am pleased to note that Forssell, of Stockholm, to-day advocates similar treatment. In cancer of the breast, operation is not undertaken until four or five weeks after the last radiation. One, two, or three post-operative treatments with radiation are given at intervals of from six to eight months.

In inoperable cases of carcinoma of the uterus, radium offers a method comparable to surgery. Radium offers, too, the possibility of a cure or definite palliation in some inoperable cases. When there is any doubt as to the extent of the disease, use radium, then operate in two or three weeks if you must. This is the treatment of choice. In the female, 30 per cent of all cancerous growths involve the uterus, and 90 per cent of uterine cancer has its origin in the cervix. Old cervical lacerations cause 95 per cent of the cervical cancers. If we as a profession imparted to our patients knowledge of the danger from an old cervical tear and other irritations, and were able to see to it that the advice was acted upon, 90 per cent of all our cancer problems would be solved. If cervical lacerations are not repaired, they should be treated by various well known methods to keep down infection and irritation, and to prevent further forma-

tion of scar tissue; but all should be repaired before the menopausal change.

Cancer is much more easily prevented than cured. It is absolutely curable in its early stages. Swanberg, after a broad survey of the methods of treatment of cervical cancer, is decidedly in favor of radiation therapy. The technic of the Radium Institute, Paris, with its use of relatively small amounts of radium for long periods, high filtration, and multiple centers, is accepted as superior to the American method of concentrated dosage. The results showed 30 per cent of cases cured for five years (Regaud), a figure which Swanberg believes can be approximated by the conscientious physician who is properly prepared to treat cervical cancer by radiation. Radium is now recognized definitely in the fight against cancer through the work of leading surgeons and clinic groups. Some of the advantages advocated for radium are: the absence of fear in the patient as a result of early treatment, low mortality, its efficacy in both operable and inoperable cases and the constant advancement and improvement in technic, while surgery is taught and practised as standardized procedures. A statistical report of various authorities (Zachell, Lindwahl, Adler, Kroening, Gauss, and Giescke) shows that the number of their cures was doubled by routine post-operative irradiation in comparison with the number of cures achieved by surgery alone. The value of post-operative radiation of the ovary and breast, for example, has been demonstrated by Seitz and others.

It is agreed that early diagnosis is the most important point in the treatment of cancer. Another important factor in our battle against such a worthy foe is to clear the body of any infected, irritated area, thus preventing a cancerous growth. Just such a thing is possible. I performed a colostomy on a patient, 55 years of age, who was suffering with cancer of the rectum. Six years earlier, I had advised a cervical repair and radium to the uterine cavity, or a panhysterectomy, but all treatment had been refused and the patient was treated for "liver disorder." She could not see the connection between the two. Six months before this report she had pain in her back and some vaginal bleeding. The cervix was fixed, with complete degeneration. The pathologic report was advanced medullary carcinoma. Radium treatment to the cervix and uterine cavity was given, after which the cervix healed perfectly. The rectum was also involved, and colostomy was performed and radium applied. If the cervix and body of the uterus had been removed, or the former repaired and radium applied to the uterine cavity to kill infection, the patient certainly would not have suffered later from an extension to the rectum.

Never perform a total or subtotal hysterectomy for menorrhagia: radium will cure these cases; it not only destroys cancer cells but kills the infection present. If hemorrhage is not corrected, then operation is in order after several radiations, and few patients will die following the operation. I irradiate all myomas and fibroids except those which are pedunculated and calcified. Afterwards, if necessary, I operate—in two or three months. I have to report almost no surgical deaths. In removing the cervix and the body of the uterus, I loosen the cervix vaginally with actual cautery throughout the length, with gauze on the index finger, completing the operation by the suprapubic route, with only four or five hemostats.

SUMMARY

The problem that confronts us, then, is how to prevent a malignant transformation of the normal cell, and, once malignant transformation has set in, how to destroy the cell. If by some means we can determine the accurate quantitative measure-

ments of the activating and depressor substances, or different cellular elements and body fluids, we may then at least feel that our feet are firmly planted on the road to a fuller knowledge in order to arrive at the origin of the entire cancer problem. This problem can be solved by making gynecologic examinations, and by always looking at the cervix as well as palpating it. Put all patients on a detoxicating diet of fruits, vegetables, and buttermilk, and give hot sodium bicarbonate enemas daily. This will clear the colon of all infection. A soapsuds enema has no place as a therapeutic agent. The majority of women complaining of nervous disorders, general tiredness, backache, mental irritations, leukorrheal discharge, constipation, and palpitation of the heart are affected by toxic poisons, generally from the pelvic organs. If you are a specialist, remember there are other organs besides the one in which you specialize. These patients usually have a congested liver and will feel better at once if given calomel followed by epsom salts next morning. All cancer patients present these complaints and frequently they admit that they have been getting worse each year. I have seen patients who have been treated for heart disease for several months. When they are examined (and thyroid disease is absent), often the real underlying cause has proved to be a lacerated cervix with accompanying gallstones. Why should not these patients develop cancer with such bombardment of bacterial and chemical toxins? Clear up the intestinal tract with proper foods; remove all points of infection and irritation. Do not wait and watch a condition to see what the outcome will be, but institute the most scientific treatment available. By doing so, you will be able to prevent many an individual from becoming a victim of cancer.

FOREIGN BODY ACCIDENTS IN CHILDREN[1]

DIAGNOSIS AND TREATMENT

By LOUIS H. CLERF, M.D., Professor of Bronchoscopy and Esophagoscopy, Jefferson Medical College, PHILADELPHIA

A MORE general use of the roentgen ray in diagnosis of pulmonary and esophageal diseases has provided a positive aid to diagnosis and has greatly contributed to early and prompt recognition of foreign bodies in the air and food passages. The accumulation of clinical observations and pathologic data in foreign body cases and the correlation of these findings by the internist, the roentgenologist, and the bronchoscopist have led to the recognition of fairly definite clinical pictures and roentgen findings. Notable among the contributors in their respective fields are McCrae, Manges, and Jackson.

Although papers setting forth the symptomatology, diagnosis, and treatment of foreign bodies have frequently appeared in medical literature, the subject continues to be of sufficient importance to merit further emphasis. Difficulties in diagnosis are rarely encountered if it is known that a foreign body has either been aspirated or swallowed and appropriate studies are carried out to bring the case to a conclusion. The greatest obstacle in diagnosis lies in our failure to think of a foreign body as a possible etiologic factor. The fact that foreign bodies are so often overlooked should make us become "foreign body-minded."

It seems superfluous to emphasize the frequent occurrence of foreign body accidents,

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

particularly in children. In the Bronchoscopic Clinics of Philadelphia, over 2,700 cases of foreign bodies in the air and food passages have been recorded. In addition to these, reports of large series of cases have been published by bronchoscopists from other parts of the country. Statistics such as these should definitely remove foreign body accidents from the category of rare diseases and medical curiosities.

SYMPTOMATOLOGY

A careful inquiry into the beginning of the patient's illness will often suggest the diagnosis. In no branch of medicine is a carefully elicited history more important. *Initial symptoms* of coughing, choking, and gagging, and at times cyanosis, are very significant and should always suggest foreign body. If the child had something in its mouth at the time that these were noted, the case should be considered as one of foreign body until proven negative. The development of respiratory symptoms immediately following an operation on the upper air and food passages is suggestive. The occurrence of difficulty with swallowing or regurgitation in a child should call for prompt roentgen study to rule out esophageal disease and particularly foreign body. Failure to make inquiries into the history *with foreign body in mind* or to evaluate properly statements made by the patient or family regarding the onset of the illness has probably contributed more to the number of overlooked foreign body cases than any other single factor. While a foreign body may be aspirated or swallowed without producing these initial symptoms, in a vast majority of the cases there is *something* to point to foreign body as a possible etiologic factor.

In aspirated foreign bodies, the development of symptoms and signs following the initial accident depends upon many factors. The most valuable, and often the first symptom to be observed, is the asthmatoid wheeze described by Jackson. Frequently this will develop immediately after the initial paroxysm; it may be the only symptom. It should always be regarded with suspicion. If it occurs after the initial symptoms, it can be considered pathognomonic of foreign body and should not be interpreted as a manifestation of suddenly acquired asthma.

The size of the object and its ability to cause bronchial obstruction are important. Foreign bodies such as common pins, which usually gravitate to a small bronchial subdivision, may give rise to no symptoms and few signs. The *symptomless interval* is misleading, for it commonly is interpreted as an indication that the foreign body, if present, has been swallowed and should no longer be a source of anxiety.

If the object is of large size it may produce partial or complete bronchial obstruction. Certain foreign bodies, such as peanuts, often produce partial obstruction and give rise to the phenomenon described as obstructive emphysema. Rounded objects, notably beans, which promptly swell in the presence of moisture, usually block a bronchus completely, producing obstructive atelectasis. Obstructive emphysema, indicating *partial bronchial obstruction,* and obstructive atelectasis, resulting from *complete bronchial obstruction,* are very readily recognized by the roentgenologist. These may be produced by any foreign body so shaped that it will cause a bronchial block of sufficient degree. It must also be recalled that these phenomena are commonly observed in endobronchial neoplasms, extra-bronchial lesions producing compression stenosis, and in many other conditions.

Vegetal foreign bodies, by reason of certain components, set up a severe laryngotracheobronchitis in young children. The peanut, which is the most commonly observed intruder in this group, produces a reaction which has been designated as arachidic bronchitis. The physical signs in

these cases may be confusing on account of the secretions present. The presence of bronchial obstruction is important and little difficulty should be encountered in its recognition by physical examination. Obviously, its cause cannot always be determined except by direct examination. Migratory foreign bodies are readily recognized if the characteristic audible slap and palpatory thud can be elicited. A widespread inflammatory reaction is frequently present, and signs of unilateral bronchial obstruction often cannot be elicited. It is important in these cases to look for signs of bilateral obstructive emphysema, the presence of which is indicative of laryngeal or tracheal obstruction.

Cough is a common symptom but one not peculiar to foreign body cases; in certain instances it is suggestive of bronchial irritation. In migratory foreign bodies, it may be paroxysmal. There is often a tendency for the patient to attempt to suppress the cough.

The common symptoms of esophageal foreign body are disturbances in the swallowing function. In the young, these are often difficult to elicit unless there is regurgitation. In larger children, solid and soft foods cannot be swallowed. It must be recalled that respiratory tract symptoms may be present in esophageal foreign body cases. These result from overflow of secretion into the airway, or the presence of a fistulous communication between the esophagus and the trachea.

In cases of foreign bodies that have entered the stomach, there usually are no symptoms present.

DIAGNOSIS

A complete history is important. The occurrence of symptoms of cough, choking, or gagging should always be suggestive. The presence of a wheeze, heard at the open mouth, particularly at the end of expiration, is indicative of something in the air passages. A complete physical examination should be made, bronchial obstruction being borne in mind. Whenever possible, these investigations should precede the roentgen studies. The roentgen examination should be complete and, in the absence of any evidence to suggest a foreign body in the air passages, the entire alimentary canal, from the nasopharynx to the tuberosities of the ischium, should be studied. In cases of metallic foreign bodies, there should be no difficulty in recognition provided proper roentgenograms have been made, however, errors in interpretation of the findings may occur. At times, a coin, or safety pin, in the esophagus is reported to be in the trachea. It should be remembered that, as a rule, flat foreign bodies such as coins, discs, open safety pins, and similar objects in the airway, are found with their greatest diameter in the sagittal plane, and, if the foreign body is in the esophagus, in the coronal plane. In non-opaque foreign bodies in the airway, it is important to observe the patient under the fluoroscope and to make roentgenograms at the end of inspiration and of expiration. Obstructive emphysema usually cannot be detected if studies are made only at the end of full inspiration.

Buttons and bones are among the more common esophageal foreign bodies found in children that may be non-opaque to the roentgen ray. In these, and in similar objects, it may be necessary to use a bismuth or barium mixture. Children usually will not swallow a barium-filled capsule. In the event that there is disagreement between the findings of the roentgenologist and the pediatrician, a direct examination should be carried out. In cases of swallowed foreign bodies that have entered the stomach, it may be difficult to ascertain if the object still remains in the stomach or is in the duodenum. The roentgenologist can positively determine this by having the patient swallow a small quantity of opaque mixture to outline the stomach.

PROGNOSIS

The prognosis is dependent on the length of sojourn of the foreign body and the development of complications. In competent hands, over 98 per cent of patients can be cured. With the aid of the double plane fluoroscope, practically all foreign bodies can be removed endoscopically.

COMPLICATIONS

Complications are rarely encountered if the foreign body accident is promptly recognized, the object localized, and removed endoscopically. Prolonged sojourn of a foreign body in the air passages will usually be followed by changes in the foreign body and in the bronchi. There is retention of secretion, suppuration, infection of the bronchial wall, and, later, pulmonary fibrosis with bronchiectasis. Cicatricial changes in the bronchus are often found at the site of lodgment. The rapidity with which these occur depends very largely on the degree of obstruction, the virulence of the contained bacteria, and the patient's protective mechanism. Sooner or later, however, certain changes will result from prolonged sojourn of a foreign object in the airway. While pneumonia is often cited as a complication of bronchial foreign body, according to McCrae, it is of uncommon occurrence. Too often the drowned lung, with retention of large quantities of pus, is confused with pneumonia. In these cases, it is interesting to note that removal of the foreign body is promptly followed by a drop in temperature and clearing up of the physical signs. This would not follow if the process were a lobar pneumonia. Pulmonary abscess is an uncommon complication.

In the esophagus, there is the ever-present danger of peri-esophageal infection. Open safety pins and other pointed objects, such as bones, may perforate the esophagus and a fatal mediastinitis may develop. Fatal hemorrhage from perforation of a large vessel may occur. In one case of open safety pin observed by the author the point penetrated the pericardium and heart muscle. In another case of long sojourn the keeper of an open safety pin eroded into the innominate artery. Early removal of the pins in both of these cases would unquestionably have prevented a fatal termination.

Foreign bodies in the stomach rarely cause trouble. Needles, large open safety pins, and long foreign bodies will often lodge in the intestines, particularly in the duodenum. Ultimately they may perforate it.

TREATMENT

This can be summed up by stating that the only method of treatment worthy of consideration is *removal by endoscopic means.* Blind methods of treatment are dangerous; there is no justification in their employment. Fluoroscopic aid, using a double plane fluoroscope, is often indispensable in the removal of metallic foreign bodies in the bronchi as well as the esophagus.

Gastric foreign bodies can be successfully removed by the gastroscope with fluoroscopic aid. Gastroscopic removal is indicated in certain pointed foreign bodies and in foreign bodies that are either too long or too large to negotiate the sharp turns in the intestinal canal. The roentgenologist is best qualified to determine this point. The most common point of lodgment is in the third portion of the duodenum, proximal to the duodenojejunal junction. With a few exceptions, a foreign body that spontaneously enters the stomach will pass without difficulty. These patients should be continued on their usual diet and laxatives should be interdicted. The foreign body should be observed daily by the roentgenologist. Surgical interference should be resorted to only when, in the opinion of the roentgenologist, the foreign body fails to make satisfactory progress.

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DISCUSSION

Dr. Kenneth D. A. Allen (Denver, Colo.): It has been my pleasure to watch Dr. Clerf remove foreign bodies from the respiratory and gastro-intestinal tracts, and it is a remarkable procedure. If a man with his experience says that he leans on the roentgenologist for interpretation, it behooves all of us to assume a great responsibility to the man in general practice who sends us films of infants' chests.

So many children are sent in without a history of a possible foreign body. In the routine reading of a child's film, if there is the slightest sign of displacement of the heart to the one side or the other, the case should be fluoroscoped. Then, if there is foreign body causing either obstructive emphysema or obstructive atelectasis, the heart will be seen to move toward the affected side on inspiration. This sign constitutes strong evidence.

DIAGNOSIS OF UTERINE AND TUBAL PATHOLOGY USING LIPIODOL

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In the more obscure uterine and tubal pathologies, the most successful means of establishing a diagnosis—without resorting to laparotomy with its dangers and discomforts, to say nothing of the expense—is through the use of an iodized oil to assist in the roentgenographic visualization of the organs of reproduction. Lipiodol, the medium the writer has used during the past three years, is ideal in that there are no contra-indications in the pathology most commonly met with—no open blood channels such as are seen in malignancy and menorrhagia.

A normal uterine shadow is triangular, the sides of the triangle and the size varying with the individual case, the apex being the cervical end and the base the uterine fundus. The uterine tubes, which leave the two basal angles of the triangle, appear as extremely thin, wavy lines until the isthmus widens into the ampulla. Their width is much augmented before discharge into the abdominal cavity. The normal uterine and tubal displacements were demonstrated in an examination undertaken to disprove the suspicion of an early pregnancy. The consequent mental relief in one case was the means of establishing a normal menstrual period within ten days.

A condition frequently found in examining a patient to determine the cause of sterility is occlusion of one or both uterine tubes at or near the cornual end or in the vicinity of the fimbriated end. In one of the writer's cases the left tube was occluded within 0.5 inch of the cornual end, while the right was occluded at the junction of the isthmus and the ampulla; both were with difficulty rendered patent surgically. But if the adhesions are recent or thin in character, the increased intra-uterine and intratubal pressure exerted by the oil will tend to separate the adhesions and make an early subsequent pregnancy not only possible but very probable.

When the normal central position of the uterus is found to be altered (excluding instrumental alterations), some unilateral uterine or adnexal pathology exists which is causing the deviation. To avoid exacerbation, the intracervical lipiodol syringe should be held in an exactly central position, with

no drag on the uterus to right or left, and no harmful up-pushing of the uterus, which tends to throw its body to one or the other side. In a case of dextroversion due to left-sided hydrosalpinx, adherent to the uterus, the syringe could not be held in a central position without causing acute discomfort and distortion.

In an infantile uterus, the tubes may or may not be occluded. In one case the effect of the examination was to stimulate the uterus and render pregnancy possible.

Intramural and intra-uterine fibromas are readily diagnosed by the alteration in the shape of the uterine triangle. When intramural fibroids are laterally placed they show an incurving of the uterine outline. The smaller the fibroid the more acute the niching. Intra-uterine fibroids would naturally show a thinning of the lipiodol in the triangle in which they are situated. If they are large enough, extramural fibroids give a picture similar to dextroversion.

The most outstanding and interesting case to visualize by uterosalpingography is the bicornuate uterus. The uterine triangle is much altered, the two cornuæ being drawn outward and upward so that the cornual ends of the tubes are at a much higher level than the uterine fundus. Other pathology may be present. In one case, the uterus was completely retroverted and both tubes were occluded at the junction of the isthmus and the ampulla.

Diagnosis of pregnancy can be made as early as two weeks after a single coitus. The uterosalpingogram has two distinctive features: the breaking of the contour of the uterine triangle (which, alone, could be due to intra-uterine fibroid — i t s e l f exclusive), and the occlusion of both tubes. In one case it was seen very readily that the lower part of the triangle was thinned out at the point at which the fertilized ovum had implanted itself. In a second case it was deemed impossible that the patient could be pregnant as abortion had been attempted and a four-day bleeding had resulted. When, some weeks later, abdominal pain and intractable vomiting overcame the patient, the case was diagnosed as typhoid fever; but the uterosalpingogram altered the diagnosis completely. At the time of the examination (exactly six weeks from the date of a single coitus) it was seen that the uterine outline was much enlarged, with marked irregularity of the triangular outline owing to the presence of the fetus (superiorly), and the more regular placenta (inferiorly, and to the right).

It has been held that uterosalpingography is liable to cause abortion in the early pregnant uterus. In neither of these cases was the pregnancy disturbed by the introduction of the lipiodol into the uterus, and the writer feels that this would be true of most cases if the physician making the examination ceased introducing the oil as soon as his patient complained of "cramps." It has been the writer's custom to make a small film of the pelvis when this complaint is made; invariably it has proved to be the right time at which to stop. I have then proceeded to make the main exposures of the case—stereoscopic films 14 by 17 inches, taken either vertically or laterally, and always on the Bucky diaphragm.

CONCLUSIONS

1. Uterosalpingography is an unrivalled means of establishing a diagnosis in uterine and tubal pathology and abnormalities which cannot be detected with any degree of certainty except by laparotomy.

2. An accurate means of diagnosing the cause, or causes, of sterility in women otherwise normal and with normal husbands.

3. Uterosalpingography is a most useful aid in establishing with certainty, with little or no risk to either the mother or the embryo, the presence of the earliest stages of pregnancy.

EDITORIAL

LEON J. MENVILLE, M.D. . . . . *Editor*
BUNDY ALLEN, M.D. . . . *Associate Editor*

THE QUESTIONNAIRE CONCERNING "RADIOLOGY"

Previous to the St. Louis meeting of 1931, Dr. W. H. McGuffin, Chairman of the Publication Committee at that time, sent questionnaires to all subscribers of RADIOLOGY, submitting inquiries as follows: (1) "Are you favorably impressed with RADIOLOGY as it is to-day?" (2) "Have you any suggestions for the improvement of the Journal?"

In Dr. McGuffin's report he stated that 50 per cent, or about 1,200, of those receiving the questionnaire responded; since then, about a hundred more replies have come in. So much for the response.

Of the replies received by Dr. McGuffin, he stated that something over 95 per cent, or 1,140 out of 1,200, expressed satisfaction and stated over the signature of the reader that he was "favorably impressed." This result is most gratifying and encouraging to all concerned; however, it is from the dissatisfied 5 per cent, or 60 out of 1,200 replies, that we look for helpful suggestions for improvement.

Since the size of the Journal has been reduced during the last six months, we may consider that we have more than met the wishes of the 28 who said it was "too ponderous," "getting too large," etc., and advised us to "strive for quality rather than quantity."

Several thought thinner paper should be used, and even more advised a tougher cover paper, the foreign subscribers especially saying that both cover and mailing envelope should be more durable stock. One subscriber, who is a frequent contributor as well, "would like to see a Journal made up of reprints, fastened together with some kind of clip, so that they can be re-arranged." So much for format.

Three of the answers advised consolidation of Journals, and 20 made suggestions as to the *writing* of papers rather than to the *publishing* of them, the latter being the problem with which we are immediately concerned.

The larger number of those making suggestions for improvement advise more clinical and less physical material, a large enough "minority report" to merit consideration. The Journal is committed to the publication of such papers as are read at the Society's Annual Meeting, and contributions, and we are guided by the expressed preference of our readers in the choice of the latter. In a large measure, abstracts of papers on physical subjects are being omitted, acting upon these suggestions.

Nine of the replies advise diagnostic rather than therapeutic papers, but nine hardly balance with the thousand and more which make no such suggestion: "objection overruled."

Eleven suggest more illustrations and three desire better ones. One suggests an index, overlooking the fact that indexes had been published every six months to that date. Three suggest just such a Subject Index as is now in preparation. About an equal number wish more abstracts and fewer; necessity has compelled us to act upon the suggestion of the latter.

It would be unfair to quote names, but it

is most gratifying to note that the most outspoken commendation is in numerous instances over the signature of a radiologist of renown—one who is unquestionably conversant with the medical literature of the world. Instances are: "To me it is very satisfactory"; "Keep up your present standard"; "No improvement necessary"; "It has no equal as a radiological publication"; "It contains excellent original articles, and a quite comprehensive abstract of the literature"; "It is an excellent continuous postgraduate course"; "I have often wondered how the Society is able to give as good a Journal as they do for the amount they receive"; "Seems to be continually improving"; "Excellent contents and make-up"; "We await the coming of the Journal each month, and appreciate it immensely," and, as a cap sheaf, this one: "I believe that the Journal as published to-day is the best of its kind—its policy, continued, will keep it so."

COMMUNICATIONS

THE PROGRAM FOR THE AMERICAN CONGRESS OF RADIOLOGY

The American Congress of Radiology is to be held in Chicago, September 25 to 30, 1933, inclusive. This Congress is intended to take the place of, or rather, combine, the regular annual meetings of the American Radium Society, the American Roentgen Ray Society, the Radiological Society of North America, and the American College of Radiology. This is done for the purposes of economizing time and expense, and, instead of compelling one to make three or four trips across the continent, to permit us to attend the Century of Progress Exposition.

It is planned to hold a Scientific Program during six days, from 9 A.M. to 2 P.M., with an intermission of twenty minutes. The remainder of the afternoons and all of the evenings, excepting one, are to be left free for attendance at the Exposition, study of the scientific and commercial exhibits, and for the holding by the various societies of their executive sessions.

It is proposed to hold the Convocation of the American College of Radiology under the management of the officers of this organization; the Convocation of the Radiological Society of North America, together with the award of its medals, under the management of the officers of this organization; to have a banquet; to have the Caldwell Lecture, arranged for by the management of the officers of the American Roentgen Ray Society, and to have a lecture on one of the outstanding radium pioneers, under the management of the officers of the American Radium Society.

Because of the fact that we are limiting the Scientific Program to four hours and forty minutes on six days, or a total of twenty-eight hours, which must include all discussions, addresses, introductions, etc., it is self-evident that the program must be somewhat limited, and that every speaker must adhere strictly to his time, this time to include the presentation of his paper as well as the presentation of lantern slides. In spite of this fact, the Program Committee and the Council which is arranging this program, desire that, so far as is practical, all advance information and conclusions be presented at this meeting. We are, therefore, asking the members of the various radiological societies to offer to the Committee any paper that will be helpful in making this Congress a great success. Also, I am asking each member who knows of advanced work being done by some other member, please to give us this information. Please make these offers as promptly as possible, for in carrying out such a large project, delays must be avoided.

GEORGE E. PFAHLER, M.D.
Committee on Scientific Program.

FIFTH DISTRICT MEDICAL ASSOCIATION OF TEXAS

This Association held a splendid Post-graduate Meeting in San Antonio, Texas, Jan. 10-12, 1933, with an attendance of some eight hundred and much enthusiasm. As expressed in the Foreword of the program: "In these times especially, when so few of us can afford either the time or the money required for post-graduate study at the medical centers, this program should supply that stimulus so necessary both for our morale and for our interest in scientific medicine." Apparently it did.

A feature of especial interest was the round table sectional meetings, two and a half hours in length, at which opportunity was given to ask questions of the speakers.

We mention only certain of the presentations of value to radiologists, as follows: "What Every General Practitioner and Specialist should Know about Recognition and Treatment of Cancer," Joseph C. Bloodgood, M.D., of Baltimore.

"Uses and Abuses of Radium in Malignancy," and "X-ray Responsibilities in Incipient Pulmonary Tuberculosis," Edwin C. Ernst, M.D., St. Louis.

"Practical Value of Intravenous Urography in General Diagnosis," William F. Braasch, M.D., Rochester, Minn.

"Bronchoscopy of Foreign Body Diseases of Lungs," Gabriel Tucker, M.D., Philadelphia.

The officers of the Association are: S. E. Thompson, M.D., of Kerrville, Texas, *President;* H. McC. Johnson, M.D., of San Antonio, *Vice-president;* T. E. Christian, M.D., San Antonio, *Secretary.*

THE AMERICAN SOCIETY OF RADIOGRAPHERS

The next annual meeting of the American Society of Radiographers will be held in Rochester, New York, from May 31 to June 3, 1933.

So many radiologists prefer to have associated with them, to do expert technical work, men and women who are members of the above-named association of technicians, that numerous physicians and physicists are always sure to be represented on its programs. It is still too early to announce the speakers, but the American Society of Radiographers has never failed to have practical, skillfully conducted meetings, vibrant with enthusiasm.

IN MEMORIAM

Alfred Leftwich Gray, M.D.

Dr. Gray, a former President of the American College of Radiology, died on October 13, 1932, after an illness of nearly two years. The *Medical Monthly* of his native State, Virginia, has printed a splendid biographical sketch of Dr. Gray, bespeaking the high regard in which his co-workers held his scholarship, attainments, and character.

ANNOUNCEMENTS

AN INCREASE IN THE SIZE OF "RADIOLOGY"

Readers will note that with this month's issue is begun what we trust is to be a steady increase in the size of the monthly issues of this Journal: eighteen pages have been added. The sharp decrease in the number of pages, which took place during the past year, was occasioned by the fact that the Society could not otherwise "balance its budget." Every possible economy has been effected with the object of turning all available funds into increasing the number of pages to be devoted to the publication of papers read before the Society and contributed by readers.

The Editor has been encouraged in his endeavor to maintain the high standard of Radiology by those who, themselves com-

petent judges of medical literature, have written him of their satisfaction in the Society's Journal, even though its size has been diminished.

Acknowledgment is due those authors who have furnished their own illustrations with the utmost good nature, since the Society has been unable to do so.

The Cole Collaborators offer a correspondence course in roentgenologic gastrointestinal diagnosis, which includes a correlation of anatomical and pathologic findings with roentgenographic findings, and an application of these to all the problems of gastro-enterology — etiology, pathogenesis, process of repair, diagnosis, and indication for medical or surgical treatment. This course consists of 22 assignments, one each week for five months. It requires at least two hours a day for the student to read the text, prepare his drawings, and write his answers, which are returned to the Cole Collaborators for correction and criticism.

Those interested may write to the Cole Collaborators, 36 East 61st St., New York City.

ABSTRACTS OF CURRENT LITERATURE

CONTENTS BY SUBJECT

THE FOLLOWING ABSTRACTORS HAVE CONTRIBUTED TO THIS ISSUE

J. N. Ané, M.D. — John E. Habbe, M.D. — E. T. Leddy, M.D. — Ernst A. Pohle, M.D.,Ph.D.
Howard P. Doub, M.D. — Hans W. Hefke, M.D. — H. C. Ochsner, M.D. — C. G. Sutherland, M.D.

CONTENTS OF ABSTRACTS IN THIS ISSUE, LISTED ALPHABETICALLY BY AUTHORS

CANCER (DIAGNOSIS)

The Incidence of Carcinoma in Certain Chronic Ulcerating Lesions of the Stomach. G. W. Holmes and A. O. Hampton. Jour. Am. Med. Assn., Sept. 10, 1932, XCIX, 905-909.

The authors believe any chronic, indurated, ulcerating lesion, occurring in the pyloric antrum within one inch of the pylorus, but without involving the pylorus, should be considered malignant until proven to be otherwise, and that proof of the absence of malignancy in such lesions is obtained only by serial section and careful microscopic examination. It is not safe to interpret such lesions as benign from roentgen examination alone or from observation on the operating table.

C. G. Sutherland, M.D.

CANCER (THERAPY)

The Application of Chemotherapy in the Treatment of Carcinoma. G. Ernst. Strahlentherapie, May 11, 1932, XLIV, 97-108.

The author briefly reports his experience with the combination of the oral administration of $LiMgJ_3$—pectin compound—with X-rays in treating malignant tumors. A total of 54 patients, all with inoperable neoplasms, are analyzed. In 40 of these, a favorable effect of the combined treatment could be noted. This was even more striking in five cases of sarcoma. An extensive bibliography is appended to the article.

ERNST A. POHLE, M.D., Ph.D.

Healing of Wounds in Tissue Irradiated Preceding Operation, with Special Consideration of Breast Cancer. O. Jüngling. Strahlentherapie, May 11, 1932, XLIV, 125-130.

In 52 patients, with operable carcinoma of the breast, observed from October, 1930, to March, 1932, the author studied the following questions: (1) Can a technic be developed to irradiate carcinoma of the breast successfully without injuring the surrounding tissue? (2) Does pre-operative irradiation render the following operation difficult? (3) How do the wounds heal in the irradiated area if radical operation is done with the knife or by the endotherm method? (4) How do the wounds heal if, after operation, the gland-bearing areas receive radium implantation?

The technic of irradiation was the same as is practised in the Radiumhemmet, Stockholm. From three to six weeks later, the operation was performed and immediately following operation radium gold needles up to 200 mg. radium element were inserted. The tumor did not increase in size after irradiation.

In about 60 per cent of the cases there was very little difficulty added to the operation. In five cases the operation was about twice as difficult because of the induration of the tissue. Seventeen cases were operated on surgically, while in 35 the endotherm method was used. Of the first 17 patients, the wounds healed without complication in 16, one having a mild erysipelas. Of the second group, two advanced cases died from heart failure following operation. In three cases necrosis appeared, apparently due to an improperly functioning diathermy apparatus. Two others showed small areas of necrosis, and in two cases which had healed *per primam*, there was a serous discharge of considerable duration. Transplantations, when necessary, took well in spite of the fact that skin from the irradiated surrounding tissue was used.

No end-results can be presented because the cases have not been observed long enough. The author, who is a surgeon, concludes that from his standpoint there is no contra-indication to pre-operative irradiation and prophylactic radium implantation after removal of the breast.

ERNST A. POHLE, M.D., Ph.D.

Old and New Theories with Regard to X-ray Dosage in Cancer. F. Hernaman-Johnson. Proc. Roy. Soc. Med., April, 1932, XXV, 774-777.

The author feels that roentgen irradiation cures principally by stimulating local and general tissue resistance. The use of a dosage destructive to tissue surrounding the malignant lesion should be limited to desperate cases. He states that the results in carcinoma of the breast can be improved only by the continuous effort to maintain the patient's resistance against possible metastasis.

H. C. OCHSNER, M.D.

The Treatment of Metastatic and Inoperable Mammary Cancer, with a Discussion of Certain Distinct Types of Metastasis. Frank E. Adair. Am. Jour. Roentgenol. and Rad. Therapy, April, 1932, XXVII, 517-531.

The discussion in this paper is limited to the treatment and results of primary inoperable, recurrent inoperable, and metastatic cancer of the breast, as carried out at Memorial Hospital, New York City. The chief forms of treatment made use of are: (1) Irradiation, both external and interstitial; (2) surgery, including palliative excision of necrotic, foul-smelling tissue, and the occasional removal of a local recurrence, lymphangioplasty, and chordotomy; (3) electrocoagulation; (4) supportive jackets, in vertebral involvement, and (5) medication in the forms of irradiated ergosterol, phosphorus, and calcium lactate.

Metastases to the axilla represent a difficult form of the disease to successfully treat, but by combining interstitial radiation with externally applied high voltage roentgen therapy to the extent of from 600 to 700 per cent S.E.D. into the center of the axillary chain of disease, satisfactory results can often be achieved without inducing a brachial neuritis.

Supraclavicular metastases, often in the form of a single fairly large node just above the middle of the clavicle, are usually responsive to a lesser amount of radiation than is necessary in the axillary involvement. Radium packs and high voltage roentgen therapy are used.

Chordotomy has been utilized with great relief to the pain-ridden patient in the occasional metastatic involvement of the brachial plexus.

Bulky parasternal metastases respond well to a 15,000 mc.-hr. radium pack supplemented by a single high voltage X-ray treatment.

In osseous metastases very effective palliation for

variable periods of time can be attained by external irradiation supplemented by calcium, phosphorus, and ergosterol for stimulation of bone repair, and supportive jackets for the collapsing spine cases. The author advocates roentgen treatment for cases clinically suggesting osseous metastases, even if definite radiographic evidence of such extension is lacking.

J. E. HABBE, M.D.

Late Results of the Fractionated Irradiation of Carcinoma of the Larynx (1922-1927): A Contribution to the Question of Protracted or Shorter Single Treatments. A. Gunsett. Röntgenpraxis, March 1, 1932, IV, 214-223.

Of 23 cases of laryngeal carcinoma treated between the years 1922 and 1927, 5 cases, which is 21.7 per cent, were cured for three years and over. The greatest number were advanced cases. Of 10 cases, with a carcinoma confined to the larynx alone, four remained cured; one for nine years, one for six years, and two for four years. In this small group the protracted type of irradiation did not seem to play an important rôle. In exolaryngeal cases in which the cancer extended above the larynx proper, protraction of the single treatment appeared to be of importance. In four cases the tumor disappeared completely, at least temporarily, with a corresponding alleviation. Lately, the author gives 3,500 r (measured on the skin through two lateral fields). The daily dose is 300 r, given in about one hour (2 mm. Cu and Al filter, 50 cm. distance). In exolaryngeal cases the entire dose is still larger, while the focal skin distance is increased to 65 centimeters.

H. W. HEFKE, M.D.

Irradiation of Mammary Cancer with Special Reference to Measured Tissue Dosage. Burton J. Lee, George T. Pack, Edith H. Quimby, and Fred W. Stewart. Arch. Surg., March, 1932, XXIV, 339-410.

The authors believe that the pre-operative external irradiation for mammary carcinoma is of value. This is shown by: (1) The occasional regression of tumors so treated; (2) the histologic changes produced, and (3) the better clinical end-results.

They believe that a sufficient devitalizing dose cannot be delivered by external irradiation alone, but that one must supplement this with interstitial irradiation. The tissue dose delivered to the tumor should be measured and expressed in skin erythema units. This dose expressed in skin erythema units can be determined, whether external or interstitial irradiation is used. The universal tissue dosage necessary to effect destruction of a radioresistant mammary cancer approximates twelve skin erythema doses.

The safest procedure is to treat all patients with mammary cancer with the same sufficient dose because (1) radiosensitivity cannot always be determined before operation, and (2) the same tumor may contain radioresistant and radiosensitive areas. These tumors vary a great deal with respect to radiosensitivity. The mammary gland itself will tolerate safely large doses of interstitial irradiation. The authors have not seen any evidence of dissemination of the disease by interstitial irradiation, and they believe that preliminary external irradiation lessens this possibility. They give all the pre-operative irradiation within a period of three weeks or less, and then wait at least six weeks before a radical amputation is performed.

Their present method for treatment of primary operable mammary cancer is external irradiation; then interstitial irradiation, and finally radical amputation six weeks later. The axilla is irradiated by: (1) Pre-operative roentgen rays or radium element packs followed by (2) interstitial gold filtered radon, distributed along the gland bearing areas.

They believe that primary inoperable cancer of the breast should be treated by proper measured doses of irradiation to insure the disappearance of the cancer in the breast and adjacent lymph nodes. This method constitutes the procedure of choice and is the only available measure for palliation and possible cure for inoperable carcinomas of the breast.

In recurrent carcinoma of the breast, most of the cases are inoperable, and these, by necessity, should be treated by radiation therapy, as it offers the only hope of arresting or eliminating the disease, or relieving many of its distressing symptoms. In a few cases these tumors are of such nature that they can be completely excised.

The pathologic changes produced in mammary cancer by external irradiation are mainly due to vascular effects. They are moderate hydropic swelling of the tumor cells, moderate atrophic degeneration, marked collagen swelling, productive arteritis, with thrombosis and calcific deposits in the vessel walls, and productive fibrosis.

The changes produced by interstitial irradiation are mainly direct effects on the tumor tissue, namely, ballooning degeneration; hydropic swelling; giant nuclei and atypical degenerative mitoses; a tendency toward squamous metaplasia, followed by sloughing; hemorrhage; infiltration by fatty macrophages, with ensuing extensive calcific deposits; often acute capillary necrosis, with resulting tumor necrosis; squamous metaplasia of normal adjacent globules of the breast; collagen swelling; productive fibrosis, and late atrophy of the residual tumor.

HOWARD P. DOUB, M.D.

CHEST (DIAGNOSIS)

Common Inflammatory Diseases of the Lungs as Depicted by the Roentgen Ray. B. R. Kirklin. Med. Clin. No. Am., May, 1932, XV, 1545-1550.

The author is of the opinion that the more com-

mon inflammatory diseases of the lungs should always occupy the foreground of the examiner's consideration and he, therefore, reviews the fundamental signs of these conditions. In the interpretation of roentgenograms of the thorax it is imperative, as a general rule, that due allowance be made for normal variations and purely secondary phenomena, and that judgment be conservative.

Incipient cases of pulmonary tuberculosis may be divided into two groups: In the first, which comprises by far the greater number, the earliest visible manifestation is an area of slight opacity in an upper lobe, more often of the right lung, just below the clavicle and in the parenchymatous portion of the lung. The shadow has been likened to a web spun by caterpillars about an outer branch of a tree. The lesions of the second group are similarly situated but are roughly spherical and usually multiple. Extremely limited, simple inflammatory or thrombotic processes, localized partial atelectasis, the residue of acute infection, or slight bronchiectasis may resemble the irregularly conical web produced by early tuberculosis.

Advanced tuberculosis in adults is made up of varying proportions of simple or conglomerate tubercles, gross nodules, caseous pneumonia, fibrosis, calcification, cavities, bronchial dilatations, local atelectasis, or compensatory emphysema, contraction of the lung, pleural thickening, adhesions, and pleural effusion. The disease tends to progress from above downward, so that the newer lesions are in the advancing margin below.

In children, primary tuberculosis produces a somewhat different pathologic picture, for the lesions tend to involve areas surrounding the hilus and lower lobes more often than in adults. Caseous bronchopneumonia, with scanty fibrosis and enlargement rather than calcification of the tracheal, bronchial, and pulmonary lymph nodes, is noted in the tuberculosis of childhood. The differential diagnosis is chiefly from bronchopneumonia, which produces a similar mottled shadow.

In miliary tuberculosis the pulmonary fields have a finely granular appearance, and the tubercles are seen as countless small, faint shadows distributed rather evenly throughout the lung fields or grouped somewhat in the upper lobes. Miliary metastasis and mild forms of pneumoconiosis are to be distinguished from this form of tuberculosis.

Little is seen in lobar pneumonia during the stage of engorgement, except some enlargement of the shadow of the hilum and intensification of the vascular markings. This is followed by a delicate, uniform veil-like shadow over the affected lobe. During the stage of hepatization the density of the shadow is increased and some part of the margin is usually sharply defined. In the stage of resolution the appearance of the involved areas has been compared to that of a thin piece of melting ice.

The posterior portions of the lower lobes are most commonly involved in bronchopneumonia, and the shadows which are scattered along the bronchovascular markings vary considerably. An early and persistent sign in this condition is elevation of the diaphragm of the affected side.

Pulmonary abscesses are usually located in the central portion of the lower lobes. In the early stage the shadow of an abscess is rather homogeneous, but when softening begins it becomes mottled.

Bronchiectasis is relatively common, and while the dilatations may occur in the principal bronchi of any lobe, they are more frequently seen in those of the lower lobes. When filled with secretions they produce shadows which resemble a bunch of grapes. Bronchography is especially valuable in demonstrating these dilatations.

J. N. Ané, M.D.

CHEST (GENERAL)

A Clinical Note on Successively Contemporaneous Bilateral Pneumothorax. Collatino Cantieri. Riv. di Patol. e Clin. della Tubercolosi, April, 1932, VI, 330-339.

Successively contemporaneous bilateral pneumothorax gives better results than bilateral successive, but not contemporaneous, pneumothorax. The lung may be kept collapsed for one or two years until a favorable condition is obtained. In producing pneumothorax the minimal effective pressure should be used. The author has noted a more rapid absorbability of air on the side treated last. A rare complication is pleuritis; even if it is accompanied by exudate, it is tolerated well.

E. T. Leddy, M.D.

The Gastrocardiac Syndrome Following Left Phrenic Exeresis. Giacomo Jurcev. Riv. di Patol. e Clin. della Tubercolosi, April, 1932, VI, 320-329.

The author reviews the literature on the gastrocardiac syndrome first described by Roemheld and adds a case of his own. This complex consists in a sense of oppression in the chest and of constriction and pain in the cardiac region. The pain is localized at the apex of the heart, more uncommonly behind the sternum, and may radiate to resemble the pain of angina pectoris. There may also be present difficulty in breathing, a sense of respiratory rigidity. There may be bradycardia and extra systoles, or tachycardia. These heart symptoms are accompanied by vertigo, nausea, and vomiting. The author thinks that in addition to the mechanical upset to the diaphragm and gastro-intestinal tract, a nervous factor in the neurovegetative system may play a rôle in this syndrome.

E. T. Leddy, M.D.